

**B.E.**

Seventh Semester Examination, 2010-2011  
**Automobile Engineering (ME-401-E)**

**Note :** Attempt any five questions. All questions carry equal marks.

**Q. 1. (a) What are the functions of the vehicle frame? Sketch and explain the salient features of a car frame.**

**Ans.** The frame is an integral structural part of an auto-vehicle chassis. It supports power plant, transmission system, steering system, wheels and tyres etc. The body is also fitted on it. Attachment of all these parts & systems may be rigid or flexible.

Rigid attachment is due to welding while flexible attachments utilize fasteners (such as bolted, screwed & riveted joints).

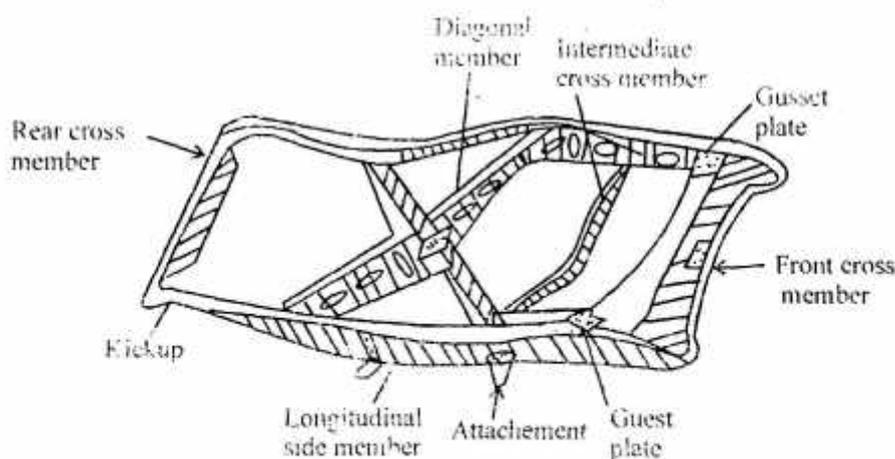
The front & rear wheels are indirectly connected to the frame by means of spring shafts. The frame is supported by a suspension system which is attached to the wheels & their connectives. This is done for comfortable riding because the large weight of vehicle supported by the spring, causes enhanced sprung weight & increased comfort.

The frame consist of various members placed in different orientations & different locations. These members made of cold rolled steel or heat-treated alloy steel are given below :

1. Longitudinal side member.
2. Front, rear & intermediate member.
3. Diagonal member.

The longitudinal member extends length wise from front to the rear. Cross-members are placed transversely along the width, while diagonal members have cross-orientation.

**Special Features of Car Frame :**



The frame is made narrow at the front end and wider on rear side. A narrow front allows short turning radius to front wheels. While wider rear allows ample shape in the body for luggage etc. The side members are

curved upward over the rear axle to form a kickup. Such arrangements keep a lower centre of gravity of the body which in turn enhances the stability of the vehicle & each end curved portion is connected to the rear leaf springs.

The frame, in autovehicles having independent front wheel suspension are heavier in front than those having rigid axle suspension. It is because there is no rigid front axle in independent front wheel suspension vehicles.

The body of vehicle is welded on frame by means of bolts nuts with washer etc. A diagonal cross member may not be there in a lightweight car or mini-car.

**Q. 1. (b) Discuss advantages and disadvantages of four wheel drive over those with only one drive axle.**

**Ans. Advantages :** The advantages of passenger cars having permanent four wheel drive over those with only one drive axle are as follows :

- (i) Even tyre wear.
- (ii) More balanced axle load distribution.
- (iii) Better aquaplaning behaviour.
- (iv) Reduced sensitivity to side wind.
- (v) An increase in the drive off and climbing capacity regardless of load.
- (vi) Particularly suitable for towing trailers.
- (vii) Stability reserves on slush & compacted snow tracks.
- (viii) Better acceleration in low gear.
- (ix) Better traction on smooth surface in all road conditions, especially in wet & wintry weather.

**Disadvantages :**

- (i) Acquisition costs.
- (ii) Around 6% to 10% higher curb weight of the vehicle.
- (iii) Generally somewhat lower maximum speed.
- (iv) 5% to 10% increased fuel consumption.
- (v) Lack of ABS-Compatibility of some systems.
- (vi) Not always clear cornering behaviour.
- (vii) Smaller boot compared with front wheel drive vehicles.

**Q. 2. Where and why do we use multiple clutches? Explain the constructional features and working of a multiple dry clutch, using neat diagrams.**

**Ans. Need of Clutch :** Clutch is an intermediate mechanism which is placed between the flywheel and the gearbox for the purpose of allowing or discontinuing the power flow from engine to the transmission system.

The clutch remains in engaged position & allows flow of power from, engine to the gear box. When the flow of power is interrupted for any reason, it is disengaged & hence the power flow discontinuous. The disengagement of the clutch is required when the gear position is to be changed or vehicle needs to be kept in neutral position.

**Multiple Dry Clutch :** Multiple dry clutch is also known as multiple clutch.

It is similar to the single plate clutch but only the difference is that it has more number of frictional & metal plate.

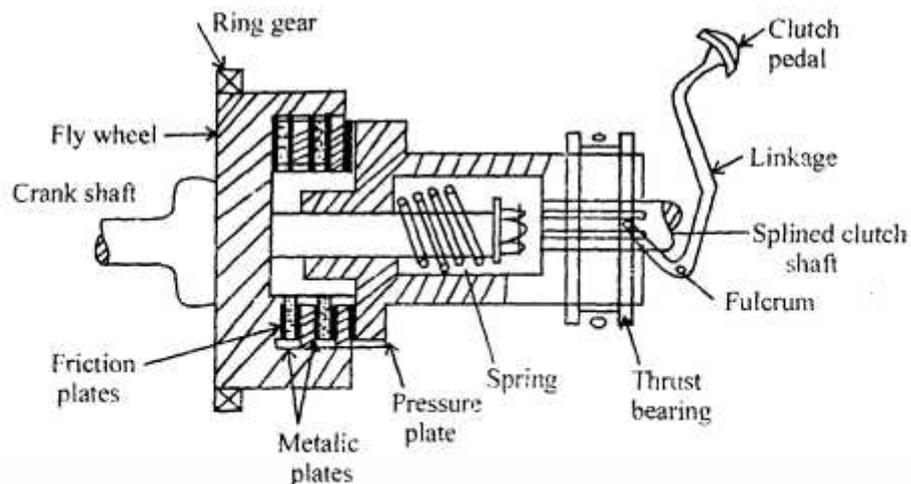
The need of multiplate clutch arises due to either (i) space limitation such as in 2 wheelers or (ii) require-

ment of high torque transmission as in racing cars & on heavy transport vehicles.

The construction of multiplate clutch is clear from the simplified diagram. It has more number of frictional plate in comparison of single plate clutch it contains two sets of frictional plates one set of plates side on splines of the pressure plate & the other slides in grooves of the flywheels. Both types of frictional plates are arranged in alternator manner.

**Working :** When the engine shaft moves. The friction force is produce in the friction lining due to axial pressure of the spring. If the torque due to this frictional is more than transmit torque.

Then there is no slip between surface & power transmit to clutch shaft from engine shaft. Transmit torque is dependent on axial force, friction constant of surface & average radius of frictional lining. For disengaging the clutch a pedal is provided to pull the pressure plate against the springs to make loose the friction plate from both sides. While there is no effort on clutch pedal. The clutch remains in engage position.



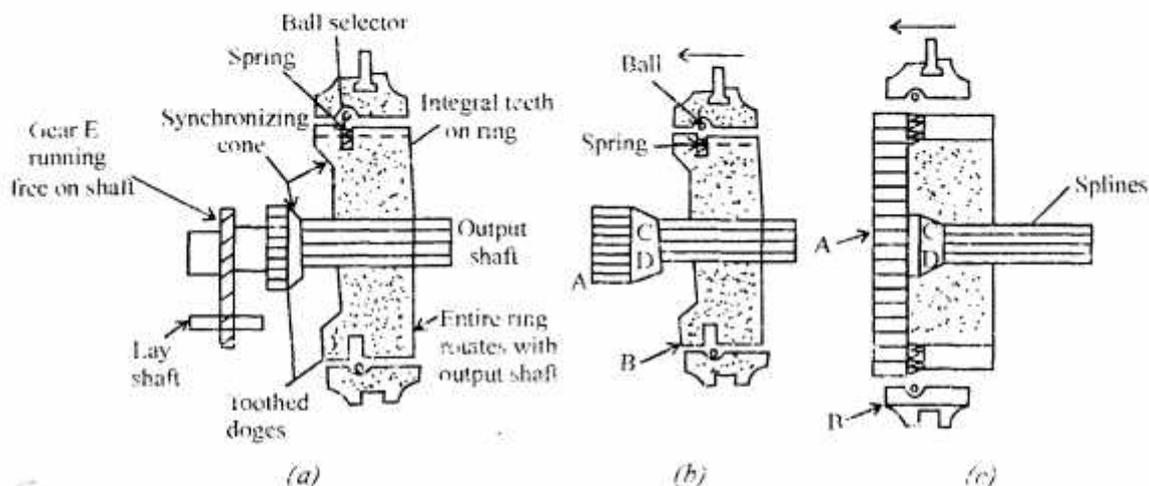
**Q. 3. What is the necessity of a gear box in a vehicle? Describe in detail function, construction on and working of a synchronous mesh gear box.**

**Ans. Necessity of Gear Box :** Gear box perform the following functions :

- (i) Gear box assists in variation of torque produced by engine in accordance with driving condition. Large torque at start of vehicle & low torque at higher speed.
- (ii) It helps in smooth running of vehicle at different speed since variation in torque induces variation in speed.
- (iii) It provides a means to vary the torque ratio between engine & road wheels.
- (iv) Gear box reverse the direction of rotation of drive output by use of a back gear. Thereby causing back motion to vehicle.

**Synchromesh Gear Box :** The modern cars use helical gears & synchromesh devices in the gear boxes, that synchronize the rotation of gears that are about to be meshed. This eliminates clashing of the gears & make gear shifting easier. The synchromesh gear box is similar to the constant mesh gear box, but the synchromesh gear box is provided with a synchromesh devices by which two gears to be engaged are first brought into frictional contact which equalize their speed after which they are engaged smoothly. In most of cars, this devices are not fitted to all gears. They are fitted only on the top gears. Reverse gears & in some cases they first gear, do not have synchromesh device.

Synchronous means matching the speeds. An automatic arrangement for matching the speed of engaging dogs is called "synchronizing". The Gearbox employing such an arrangement is termed as "synchronesh gear box." The synchronizing between engaging dog & the appropriate gear is achieved by a synchronizing assembly called "synchronizer."



(a) Disengaged Comes & Dogs (b) Engaged Comes But Diverged Dogs  
(c) Engaged Comes & Dogs of Moving Selector

The construction & working principle of a typical synchronizer is from fig.

It consists of mainly three parts :

- (i) N Ring having internal teeth.
- (ii) Synchronesh comes; male C and female D.
- (iii) Tootheed dogs A and B.

The ring is normally held in place by spring loaded balls. It rotates with output shaft & can also be slide along the splines cut on this shaft.

From fig. (a) shows disengaged position. Neither the male synchronizing cone C meshes with its female cone D, nor the male tootheed dog A overrides the female tootheed dog B. The input shaft, layshaft & gears are running trees.

When selector moved in the direction then synchronizing comes C & D come into contact & the friction between them either speeds-up or slows down the gear E w.r.t. out shaft.

A further movement of selector causes tootheed dogs A & B to override by overcoming spring loaded balls and thus gear E is locked to the output shaft.

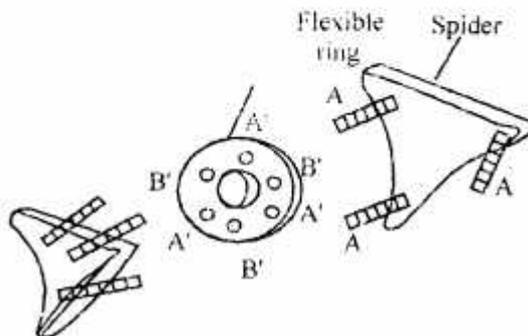
**Q. 4. (a) What is constant velocity universal joint? Explain the principle of working of any such joint.**

**Ans. Universal Joint :** Universal joint is also known as universal coupling is used to connect two shafts which are inclined to each other & whose axes are intersecting. Universal joints are designed to transmit torque under various loadings & when drive line angle changes due to movement of drives shaft or drive axles during the vehicle operation. It is widely used an autovehicles. it functions very well for smaller intersecting angle between the shafts but can operate upto 20°.

**Types of Universal Joint :**

- (i) Hooke's joint with needle roller bearings.
- (ii) Pot-type universal joint.
- (iii) Flexible ring universal joint.
- (iv) Perfect circle U-joint.
- (v) Constant velocity joint

**Flexible Ring Type Universal Coupling :** This is a cheap & simple construction joint comprising of a flexible ring & three-arm spiders, one on each side of the ring. Each of two spiders is attached on the two connecting shafts. The bolts A & B on the spiders, fix into six holes A' & B' cut into flexible ring.



**Advantages of Flexible Ring U-Joint :**

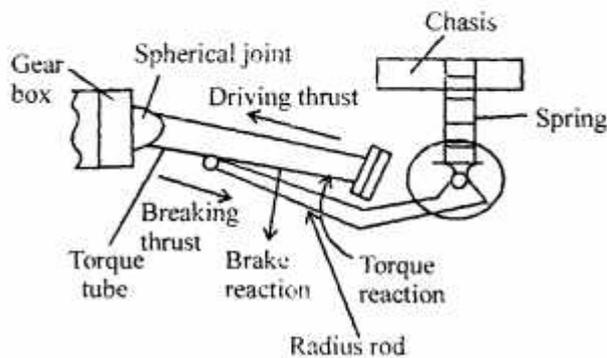
- (i) Lubrication is not needed in them.
- (ii) Small axial movements is possible.

**Disadvantages :**

- (i) Angle between the shaft has to be of smaller value.
- (ii) Design demands a larger size if greater torque is to be transmitted.

**Q. 4. (b) Describe the constructional details and operation of the Torque Tube Drive.**

**Ans. Torque Tube Drive :**



The leaf spring used in Hotchkiss drive is severely burdened since it has to perform additional duties of resisting torque reaction & the thrusts. This problem has been eliminated in torque tube drive by incorporating

a hollow tube between the axle casing and a cup fixed on the frame.

Now the torque reaction, braking torque & the driving thrust are being taken by this tube leaving the spring to sustain only the side thrust & body weight.

The spring is supported is shackle at both its ends. This saves the spring from being deflected in one of the other direction. There is no risk for bending of the propeller shaft. This in turn, enables use of a propeller shaft with a slip joint. The connection of torque tube with the cup is through a spherical joint. The propeller shaft is fully enclosed within the torque tube & cannot be seen rotating from outside which is possible in case of hotchkiss drive. A torque tube drive has been employed on Buick : Lesabre, Electra, Invicata & Rambler Car models.

**Q. 5. What is independent suspension? Explain any three methods to achieve the same in front axle of automobiles. Compare the same with rigid suspension.**

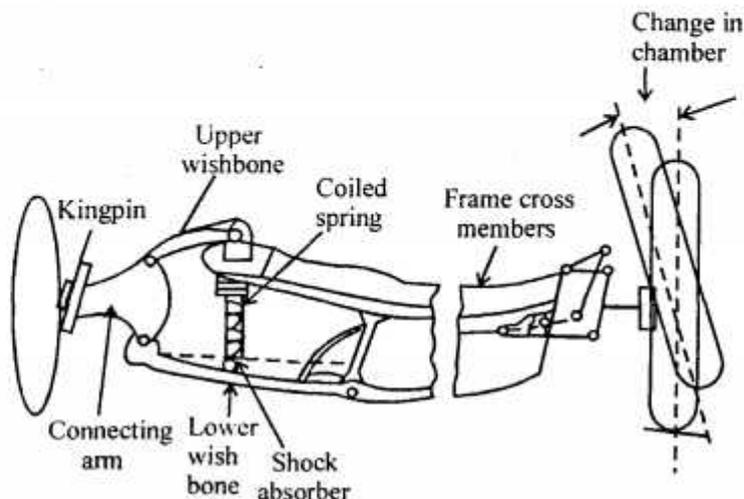
**Ans. Independent Suspension :** These system may employed either a helical coiled spring or Torsion bar & the suspension may be provided on front wheels or on rear wheels or on all the wheels of vehicle.

- (i) When it provided on front wheel then it is known as Independent Front Suspension (IFS)
- (ii) When it provided on rear wheel then it is known as Independent Rear Suspension (IRS).

**Independent Front Suspension :** This system is adopted on front axles of all vehicles & its construction in very simple.

**Different Types of IFS are :**

- (i) Divided axle type.
  - (ii) Wish bone (unequal links) types.
  - (iii) Mac Pherson struct types.
  - (iv) Vertical slide type
  - (v) Trailing arm type
  - (vi) Equal links type.
- (i) Wishbone Type :**



It consist of the following main parts :

- (i) Smaller upper wishbone and longer lower wishbone.
- (ii) Connecting arm to connect upper & lower wishbone with the king pin.
- (iii) Coiled spring enclosing a shock absorber.
- (iv) Frame cross-member on which are pivoted the upper & lower wish bone.

The spring & shock absorber are connected between the lower wishbone & under side of frame. The shape of both wishbone arm is V-type like as the shape of chicken's wishbone.

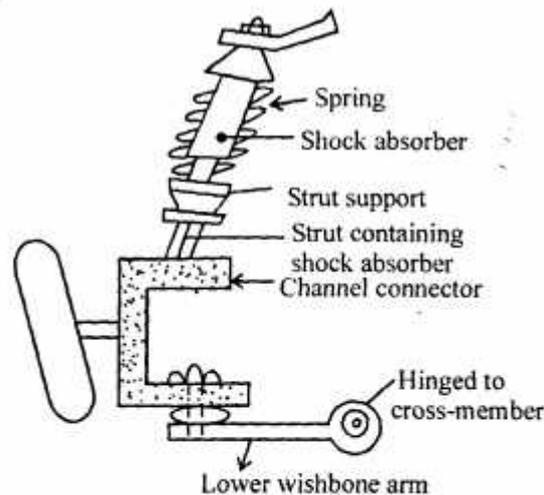
During motion, wheel encounters a bump, the weight of the vehicle is transferred to the coil spring through connecting arm upper wish bone & cross-arm. This is then transmitted to lower withbone which pushes-up the shock absorber. Consequently, it damps down the vibration in the vehicles.

The wishbone arm are shaped in V-profile, for correct positions of wheels, resist force produced due to acceleration, braking & cornering.

Main advantages of unequal arm lower & upper arm are :

- (i) To maintain a non-varying wheel track (width between two wheels).
- (ii) To minimize tyre scrubbing & its wear.

(i) **Mac Pherson Type** : It consist of a lower wishbone only whereas the upper wishbone has been replaced by a strut (member under compression).



One end of the lower wishbone is hinged to the cross member of vehicle's frame while the other end is fastened to a channel shaped connector.

This connector is centrally attached to the stub axle & strut on its upper side. The strut end are so shaped that they hold on the shock absorber & the coiled spring enclosing it.

This arrangement required less space in front, therefore it is used in front wheel drive vehicles. It provided more space for the engine. The road safety & riding comforts are also increased as acceleration, braking and cornering forces are minimised due to better wheel alignment.

**Compare Independent Suspension Versus Rigid Axle Suspension :**

S. No.	Description	Rigid Axle Suspension	Independent Suspension
(i)	Condition of axle & wheels when one of the wheel meet a bumper pit.	Axle tilts & wheels no longer remain vertical.	Axle does not tilt & wheels remain vertical.
(ii)	Road adhesion	Decreased	Increased
(iii)	Riding comfort	Reduced	Increased
(iv)	Stability of the vehicle	Disturbed	Maintained safe
(v)	Effect on wheel	Wheels may wobble	No change of wheel wobbling
(vi)	Type of spring used.	Lead spring	Helical, Torsion bar.

**Q. 6. (a) Describe the construction and working of power steering gear with a neat sketch.**

**Ans.** Almost all modern cars are equipped with power steering instead of manual steering. The power steering is increasingly becoming popular on light, medium & heavy vehicles also since it ensures :

- (i) Lesser steering effort.
- (ii) Reduced driver fatigue.
- (iii) Efficient absorption of shocks.
- (iv) Better directional stability.
- (v) Higher maneuverability.
- (vi) High performance
- (vii) Enhanced safety.

The power steering system take assistance of hydraulic power in valid manners for their operation. They became operative when the manual effort exceeds about 1 kg f (10N). It means that the driver's effort is analogous to a touch of the steering wheel only.

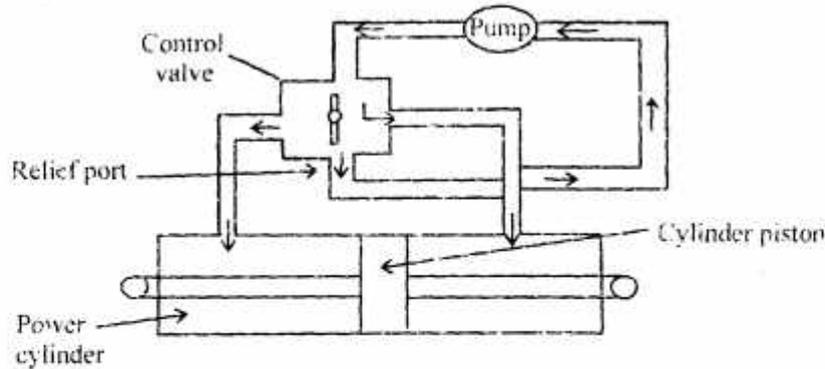
The system is designed such that if power system fails, it can be operated manually. In this situation the driver's effort will be more (about 40-50 kgf) such as in manual steering.

**Principle of Power Steering :** Power steering is one type of hydraulic device for utilizing engine power as steering effort. Consequently, the engine is used to drive a pump to develop fluid pressure. This pressure acts on a piston within the power cylinder so that the piston assists the rack effort.

If more steering force is required the pressure must be raised.

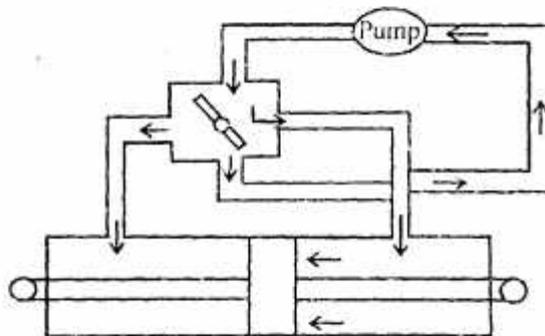
The working principle of a power steering in neutral & in turning condition can be understood as follows :

**Neutral (Straight-Ahead) Position :**



Fluid from the pump is sent control valve. If the control valve is in natural position, all the fluid will flow pass through the control valve into relief port and back to pump. At this time, hardly any pressure is created and because the pressure on they cylinder piston is equal on both sides, piston will not move in either direction.

**When Turning :**



When steering main shaft is turned in either direction the control valve also moves, closing one of the fluid passages. The other passage then open wider, causing a change in fluid flow volume & at the same time pressure occurs between both sides of piston & the piston moves in the direction of lower pressure. Thus, the fluid in that cylinder is forced back to the pump through the control valve.

**Q. 6. (b) What do you understand from the term 'backlash in steering gears? Sketch any one steering gear and explain the constructional features provided to adjust backlash.**

**Ans.** Backlash sometimes called cash or play, is clearance between mating components. Sometimes described as the amount of lost motion due to clearance or slackness when movement is reversed and contact is re-established.

**For Example :** In a pair of gears, backlash is the amount of clearance between mated gear teeth.

The backlash should be zero, but in actual practice some backlash must be allowed to prevent jamming. It is unavoidable for nearly all reversing mechanical couplings, although its effect can be negated. Reasons for requiring backlash include allowing for lubrication, manufacturing errors, deflection underload & thermal expansion.

Factors affecting backlash required in a gear train include errors in profile, pitch, tooth thickness, helix angle and center distance & run out.

Backlash is most commonly created by cutting the teeth deeper into the gears than the ideal depth. Another way of introducing backlash is by increasing the center distances between the gears.

Backlash due to tooth thickness changes is typically measured along the pitch circle & is defined by,

$$b_t = t_i - t_a$$

Where,  $b_t$  = back lash due to tooth thickness modifications.

$t_i$  = tooth thickness on the pitch circle for ideal gearing (nolack lash)

$t_a$  = actual tooth thickness.

Backlash, measured on the pitch circle, due to operating center modifications is defined by :

$$b_c = 2(\Delta C) \tan \phi$$

Where,  $b_c$  = Backlash due to operating center distance

$\Delta C$  = Difference between actual and ideal operating center distances.

$\theta$  = Pressure angle

If the pinion is smaller than the gear it is meshing with than it is common practice to account for all of the backlash in the larger gear. This maintain much strength in pinion's teeth. The amount of a material removed when making the gear depends on the pressure angle of the tooth for a  $14.5^\circ$  pressure angle the extra distance the cutting tool is moved is equal to amount of backlash desired. For a  $20^\circ$  pressure angle the distance equals 0.73 times the amount of backlash desired.

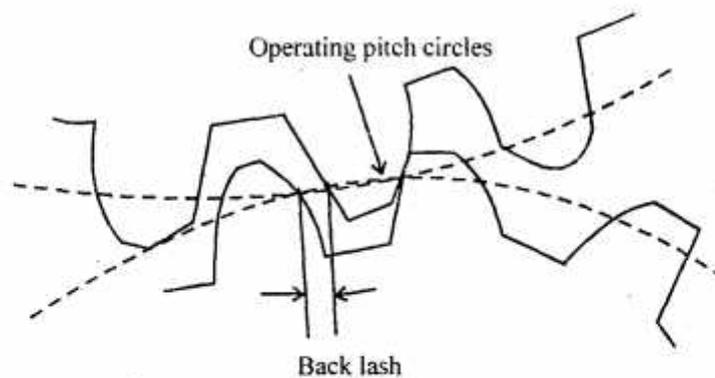


Fig. Transverse Operation

**Q. 7. (a) Describe the construction and working of disc brakes. Compare the same in detail with drum brakes.**

**Ans.** Disk brake consists of a cast iron disc bolted to the wheel hub & a stationary housing called copper.

**Construction :** A disk brake resembles a flat clutch fitted on each wheel. Disk brake is referred as spot brake. It consist of the following main parts :

- (i) Caliper or cylinder casing ; outer and inner
- (ii) Rotor disk.
- (iii) Piston

- (iv) Friction pad
- (v) Pad supporting plate.
- (vi) Bleeder plug.

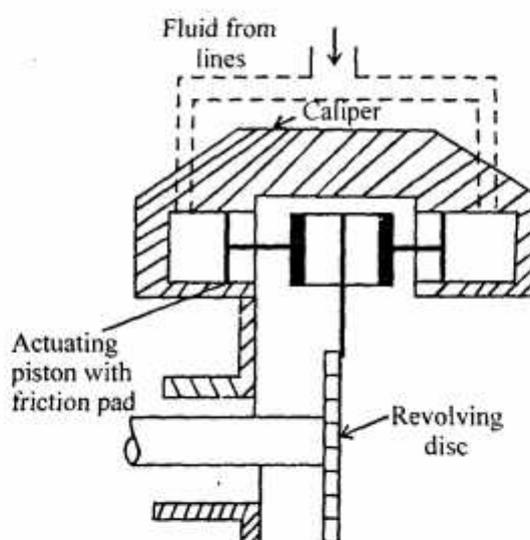
The disc brake assembly also encloses piston seal, dust boot, pad wear indicator, anti squirrel shim etc.

The cylinder casing is made in two halves named outer & inner cylinder & resembles a caliper. That why disc brake is named caliper type. The caliper is attached to the axle housing in a rear wheel brake & to the steering knuckle in a front-wheel brake. The rotor disc is connected to the road. Wheels through axle shaft. The assembly houses two friction pads. One on each side of the disc. These pads are held in position by steel pad plates.

**Working :** The disc brakes are operated hydraulically. When the vehicle is to be braked, the brake fluid pumped by the master cylinder-brake pedal system enters into the caliper through inlet tube. It then flows through the oil passages provided therein & exerts pressure on the pistons.

The pressure pads stops rotation of the disc & hence the axle shaft stops.

When the brakes are to be released, the compression springs force back the pistons to release pressure form the friction pads.



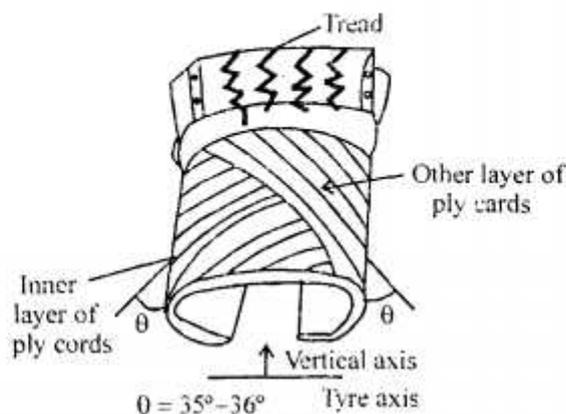
**Comparison between Drum Brakes & Disk Brakes :**

(i)	Life of friction material	Reasonable (about 15000 km)	Reasonable (about 25000 km)
(ii)	Visibility of wear from outside.	Not possible	Can be seen at a glance.
(iii)	Heat dissipation	Inferior	Better
(iv)	Weight	Bulky	Lighter (= 25%)
(v)	Cooling	Very slow	Efficient due to exposure

(vi)	Water & dirt collection	Accumulates	to atmosphere.
(vii)	Temperature effect.	Drum expands, tends to separate out from livings.	Self-cleaning.
(viii)	Self-energizing action.	Exists	Uneffected
(ix)	Brake pedal effort.	Higher	Absent
(x)	Resistance of fading	Fair	Proportional to retardation
	Force needed to apply brake.	Comparatively less	Excellent
(xi)	Nature of wear	Non-uniform	More, since brakes are not self energizing.
(xii)	Shape of friction lining	Curved	Uniform.
			Straight.

**Q. 7. (b) Compare in detail the radial-ply and the cross-ply tyres.**

**Ans. (i) Bias Ply or Cross Ply Tyres :** In this construction, the nylon cords make an angle  $\theta$  with respect to vertical axis. The inclination of cords is such that they look to joint 2 & 8, 4 & 10 on the watch.

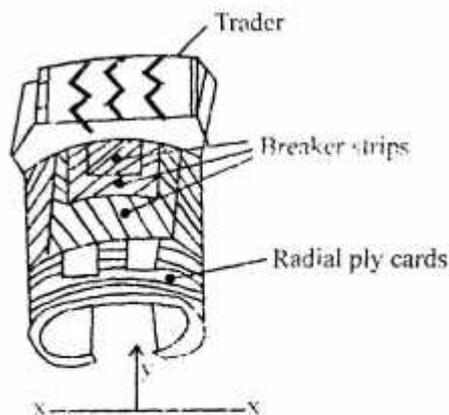


It means inclination of about  $35^\circ - 36^\circ$  from the vertical made by one layer while the same angle in opposite direction is made by other layer. The cords are un-woven so as to minimize rubbing between the two layer. If the cords are woven similar to a cloth fabric, the inner layer scrubbing will result in heat generation, thereby causing damage to the tyre.

**(ii) Radial Ply Tyre :** In this construction, the basic structure is of ply cords which placed along the direction xx of the tyre axis.

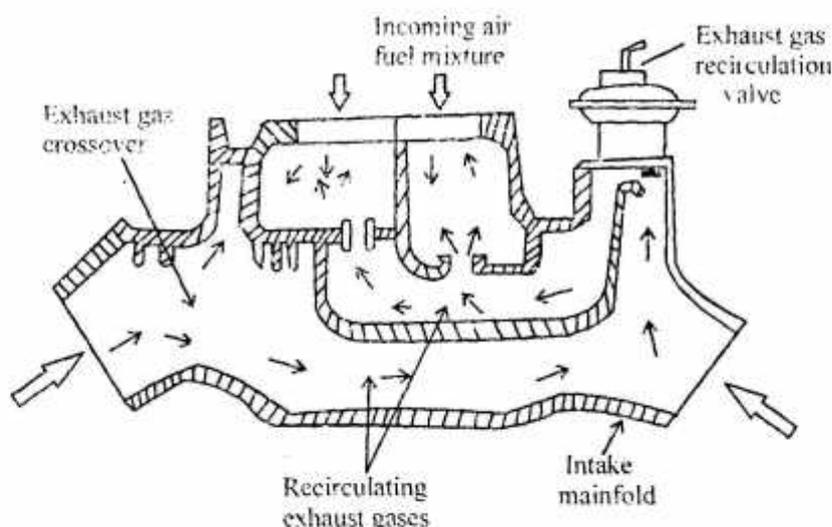
The orientation of cord is such that they joint 3 & 9, 9 & 3 on the watch i.e., they are at right angles to y-axis.

The use of radial plies alone may not provide the desired lateral stability as the ride will be very soft, a number of breaker strips are incorporated to run over than along the circumferential direction of the tyre. The brakes strips are made of inextensible but flexible material. The behaviour of brakes strips is analogous to a girder which reinforces the construction in its own plane. Its involvement is essential for directional stability too.



Q. 8. (a) Explain Exhaust Gas Recirculation systems used in automobiles.

Ans.



Exhaust Gas Recirculation (EGR) is an emission control systems which reduces the amount of oxides of nitrogen ( $\text{NO}_x$ ) produced during combustion. Since peak combustion chamber temperature is dependent on ignition timing, the spark timing control systems meet  $\text{NO}_x$  control requirements. EGR were designed as a better method to control  $\text{NO}_x$  than the spark timing controls. Small amounts of  $\text{NO}_x$  are formed at temperature below 1645k & these quantities can be easily controlled. But once combustion chamber temperature becomes 1645K or higher, more  $\text{NO}_x$  is formed.

The peak combustion chamber temperature can be lowered by two ways to prevent  $\text{NO}_x$  formation. One is to retard spark timing slightly. The more efficient method is to dilute the incoming air-fuel mixture with a small amount of inert gas.

Since exhaust gas are relatively inert, they are used to dilute the air-fuel mixture in the cylinder to lower the combustion chamber temperature. Small quantities of exhaust gas (6 to 10%) from the engine's exhaust ports are

routed to the intake manifold. Since exhaust gas contains no oxygen, the resulting air-fuel exhaust gas mixture does not produce as much heat when ignited as an undiluted air-fuel mixture produces. The amount of NO<sub>x</sub> produced at low engine speeds is very small, hence exhaust recirculation is not desirable at idle. Also it is undesirable during high speed driving at wide-open throttle, to achieve efficient operation & good driveability. Maximum recirculation is required during crising & acceleration at speeds between 48 to 112 kmph. When NO<sub>x</sub> formation is highest. At low engine temperature, NO<sub>x</sub> formation is also low and hence recirculation is avoided to produce fast warm-up & better driveability.

**Q. 8. (b) What purpose is served by a catalytic converter? Sketch and explain the construction and working of a 3-way catalytic converter.**

**Ans. Catalytic Converter :** A catalytic converter is a device used to reduce the toxicity of exhaust emissions from an internal combustion engine. Inside a catalytic converter, a chemical reaction in which noxious by products of combustion carbon monoxide, unburned hydrocarbons & oxides of nitrogen are converted to less-toxic or inert substance such as carbon dioxide, hydrogen, nitrogen & oxygen. Catalytic converters are still most commonly used in motor vehicle exhaust system. Catalytic converter are also used on generator sets, forklifts, mining equipment, trucks, buses airplanes & other engine-equipped machines.

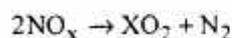
**Types of Catalytic Converter :**

- (i) Two-way catalytic converter
- (ii) Three way catalytic converter.

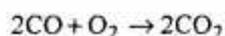
**Three Way Catalytic Converter :** Three way (oxidation reduction) catalytic converter have been used in vehicle emission control systems that effectively require three-way converters on gasoline-powered vehicles.

A three way catalytic converter has three simultaneous tasks :

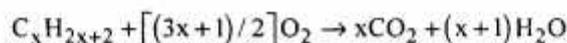
- (i) Reduction of nitrogen oxides to nitrogen and oxygen :



- (ii) Oxidation of carbon monoxide to carbon dioxide :



- (iii) Oxidation of unburnt hydrocarbons (HC) to carbon dioxide & water,



These three reactions occur most efficiently when the catalytic converter receives exhaust from an engine running slightly above the stoichiometric point lies between 14.6 & 14.8 parts air to 1 part fuel, by weight, for gasoline. Engine fitted with 3-way catalytic converter are equipped with a computerized closed loop feedback fuel injection system using one or more oxygen sensors.

3-way catalysts are effective when the engine is operated with in air fuel ratios near stoichiometry, such that exhaust gas lies between rich (excessful) & lean (excess oxygen) conditions.

Under lean condition, there is excess oxygen & the reduction of NO<sub>x</sub> is not favored. Under rich conditions the excess fuel consume all oxygen prior to the catalyst. Thus, only stored oxygen is available for the oxidation function.

**Oxygen Storage :** 3-way catalytic converters can store oxygen from the exhaust gas stream, when oil-fuel ratio goes lean. When in sufficient oxygen is available from the exhaust stream, the stored oxygen is released and consumed. A lack of oxygen occurs either when oxygen derived from NO<sub>x</sub> reduction is unavailable or certain monoverse such as hard acceleration enrich the mixture beyond the ability of the converter to supply oxygen.

**Unwanted Reactions :** Can occurs in the 3-way catalyst, such as formation of odiferous hydrogen sulfide and ammonia. It is difficult to eliminate the by products entirely sulfur-free or low sulfur fuels eliminate or reduce hydrogen sulfide.

For Example : When control of hydrogen sulfide emissions is desired nickel or manganese is added to wash coat. Hydrogen sulfide is formed when the washcoat has absorbed sulfur during a low temperature part of the operating cycle, which is the released during the high temperature part of cycle and the sulfur combines with HC.

