

B.E.

**Seventh Semester Examination, Dec-2008
AUTOMOBILE ENGINEERING**

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

Q. 1. (a) Discuss in detail classification of automobiles giving typical examples in each case.

Ans. Classification of Automobiles :

1. Use :

- (i) Auto cycles.
- (ii) Motor cycles, scooters.
- (iii) Cars, Jeeps.
- (iv) Buses & trucks.

2. Capacity :

- (i) Heavy transport vehicles (H.T.V.). Examples are trucks & buses.
- (ii) Light transport vehicles.

3. Make and Model :

- (i) Bajaj, Royal Enfield, Honda, etc.
- (ii) Premier Padmini, Standard, Hindustanm, Ambassadors, Maruti 800 etc.
- (iii) Tata, Land Rover, Ford, General Motors, Nissan etc.

4. Fuel used :

- (i) Petrol vehicles
- (ii) Diesel vehicles.

5. Body Styles :

- (i) Closed cars such as saloon, coupe, etc.
- (ii) Open cars like sports car, convertible cars etc.
- (iii) Special styles such as estate car, station wagon, etc.

6. Wheels :

- (i) Two wheelers.
- (ii) Three wheelers.
- (iii) Four wheelers.

- (iv) Six wheelers

7. Drive :

- (i) Whether the vehicle can be driven sitting towards right or left side.
- (ii) Whether the front axle, rear axle or both axles are driving axles.

8. Transmission :

- (i) **Conventional**, in which ordinary crash type gear box is used. The examples are, all Indian cars.
- (ii) **Semi-Automatic** having a pedal transmission using manual operations of the standard gear box, with automatic clutch control.
- (iii) **Fully-automatic** employs transmission that uses combination of epicyclic gear trains & torque converters.

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

Ans. The main advantage of the four wheel drive is that when the front wheels fall into a ditch, they can be driven out, being power driven. In the case of ordinary two wheel drive, where only the rear axle is the live axle, the car will have to be reversed in such a situation but even then it will not be certain always that the front wheels would come out. Of course, this advantage has to be paid for in terms of higher initial cost as well as additional running cost because of extra fuel consumption.

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

Ans. Multiple Clutch :

It is an extension of single plate type where the number of frictional and metal plates is increased. The increase in the number of friction surfaces obviously increases capacity of the clutch to transmit torque, the size remaining fixed. Alternatively, the overall diameter of clutch of the clutch is reduced for the same torque transmission as a single plate clutch. This clutch is, therefore, used in some heavy transport vehicles & racing cars where high torque is to be transmitted. Besides, this finds application in case of scooters and motor cycles, where space available is limited.

A simplified diagram of multiplate clutch is shown. The construction is similar that of single plate except that all the friction plates in this case are in two sets, i.e., one set of plates slides in grooves on the flywheel and other one slides on splines on the pressure plate. Alternate plates belong to each other.

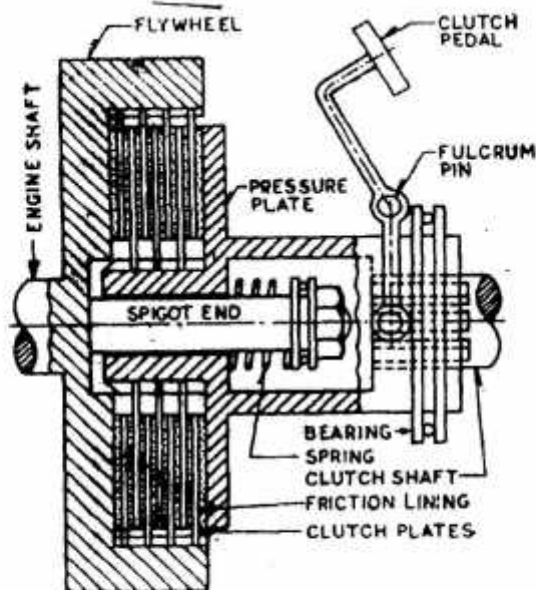


Fig. Multiplate Clutch

Q. 3. (a) Explain clearly the necessity of a gearbox in a vehicle.

Ans. The main functions of gear box are :

1. At low speeds, the torque produced by an I.C. engine is very small, which increases with increase of speed, peaks at some optimum speed and starts decreasing beyond that.

Thus, the main purpose of the transmission is to provide a means to vary the leverage or torque ratio between the engine & road wheels as required.

2. The transmission also provides a neutral position so that the engine and the road wheels are disconnected even with the clutch in the engaged position.
3. A means to back the car by reversing the direction of rotation of the drive is also provided by the transmission.

Q. 3. (b) Describe the common features and major differences in a constant mesh and a synchromesh gear box.

Ans. The constant mesh gear box has following advantages :

1. As the gears have to remain always in mesh, it is no longer necessary to use straight spur gears. Instead, helical gears are used which are quieter running.

2. Wear of dog teeth on account of engaging or dragging is reduced because here all the teeth of the dog clutches are involved compared to only two or three teeth in the case of sliding gears.

Synchromesh gear box :

This type of gear box is similar to the constant mesh type in that all the gears on the mainshaft are in constant mesh with the corresponding gears on the layshaft. The gear on the layshaft are fixed to it while those on the mainshaft are free to rotate on the same. Its working is also similar to the constant mesh type, but in the former there is one definite improvement over the latter. This is the provision of synchromesh device which avoids the necessity of double declutching. The parts which ultimately are to be engaged, are first brought into frictional contact which equalizer their speed, after which these may be engaged smoothly.

Q. 4. Explain 'hotchkiss drive' and 'torque tube drive.' Compare their construction, merits and demerits.

Ans. Hotchkiss Drive : In this case the springs besides 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 also a sliding joint. The spring is fixed rigidly in the middle, to the rear axle. The front end of the spring is fixed rigidly, while the rear end is supported in a shackle. The driving thrust is transmitted to the frame by the front half of the springs.

Due to torque reaction, the spring deflects. Thus, torque reaction is taken up by the springs. Similarly, to take up the braking torque the springs would deflect in opposite direction. When the springs deflect, the bevel pinion also changes its position. Therefore, if there is only one universal joint at the front end of the propeller shaft, it will bend under this condition. To avoid this, another universal joint at the rear end of the propeller shaft is used.

Again when the rear axle moves up & down, it has to move in a circle with the front spring support at the frame as centre. But for the propeller shaft motion, the centre is at the front universal joint. This means that during this movement of the rear axle, the length of the propeller shaft has to vary. This is provided for by means of a sliding joint in the propeller shaft.

Torque Tube Drive : In this type of drive, the spring takes 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 is fixed to the frame. Since in this case the torque tube takes the torque reaction, the centre line of the bevel pinion shaft will not shift and further it will always pass through the centre of the spherical cup if the propeller shaft is connected to the gear box by means of a universal joint situated exactly at the centre of the spherical cup. In such a situation, no universal joint is needed 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. Clearly torque reaction and the driving thrust are taken by the torque tube.

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 : When a vehicle with rigid axle suspension encounters road irregularities, the axle tilts and the wheels no longer remain vertical. This causes the whole of the vehicle to tilt on one side. Such a state of affairs is not desirable. Apart from causing rough ride, it causes 'wheel wobble'. The road adhesion is also decreased. To avoid this the wheels are spring independent of each other, so that tilting of one does not effect the other.

SUSPENSION SYSTEM

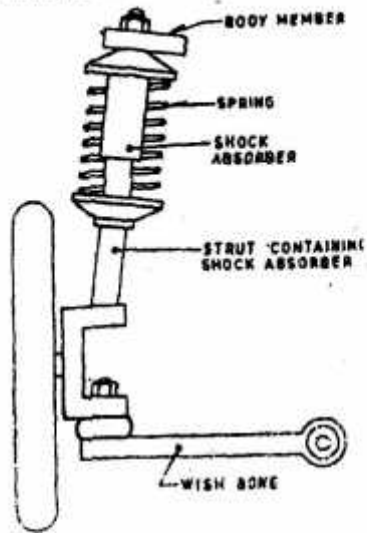


Fig. 7.33. MacPherson strut suspension.

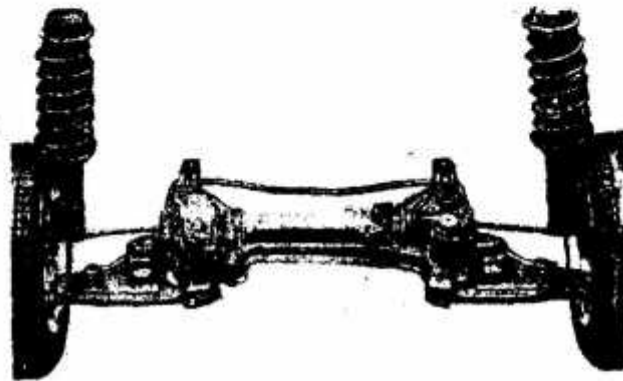


Fig. 7.34. MacPherson strut front suspension.
(Courtesy—Volkswagenwerk, Germany)

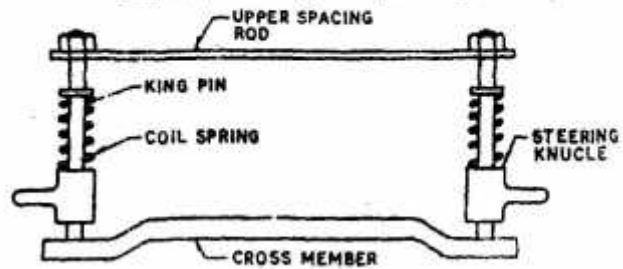


Fig. 7.35. Vertical guide suspension.

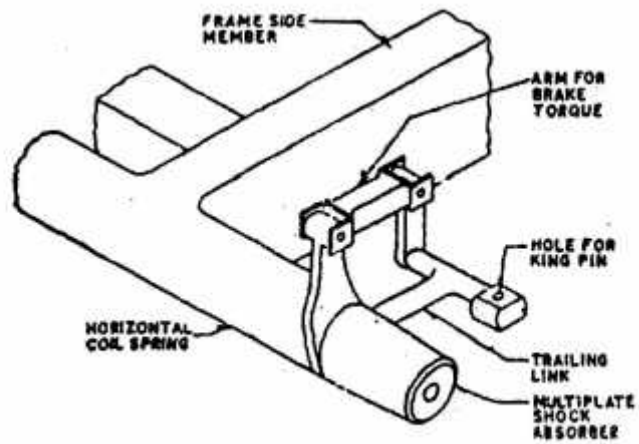


Fig. 7.36. Trailing link suspension.

Besides, the independent suspension also has the following advantages over the rigid axle type suspension.

1. The elastic strain energy per unit spring weight stored in a coil or torsion bar spring is greater than in case of a semi-elliptic leaf spring, which means lighter springs can be used in case of independent suspension.
2. In case of independent suspension, unsprung weight is reduced, which ultimately reduces the tyre scrap and hence increases tyre life.
3. Compared to the rigid axle type, softer springs can be used without increasing rolling effect. Soft springs improve ride comfort.
4. Improved steering precision since wheel movements are not linked. Caster action is reduced and the wheel travel path is controlled more accurately.
5. In case of independent suspension it is possible to locate the springs apart enough to obtain under-steer conditions, which is always preferred to oversteer condition.
6. With independent suspension, steering geometry is not altered with spring deflection as in case of conventional rigid axle suspension where effect is especially noticeable during braking or acceleration.
7. Since in this there is no solid axle beam, which required clearance for its vertical movements, the engine and the chassis frame can be placed relatively lower which means engine position can be moved forward resulting in more space for passengers.

Vertical Guide Suspension :

The kingpin is attached directly to the cross member of the frame. It can slide up or down, corresponding to the up and down motion of the wheel, thus compressing or elongating the springs. In this the tracks, wheel base and wheel attitude remain unchanged, but the system is making disadvantage of decreased stability.

Trailing Link Suspension :

In this type of suspension, a coil is attached to the trailing link which itself is attached to the shaft carrying the wheel hub. When the wheel moves up & down, it winds and unwinds the spring. A torsion bar has also been used in certain designs in place of the coil spring.

This system does maintain the camber and the wheel tracks constant. However, the distance between the front and the rear wheels does change. Difficulty to remedy this defect is the main reason for its very limited

use in actual practice.

Sprung half axle suspension :

In this wheels are mounted rigidly on the half axles, which are pivoted on their ends of the chassis member at the middle of the car. The main disadvantage of this system is that up & down movement of the wheel cause the camber angle to vary.

Q. 6. Explain the terms : Camber, Castor, Steering axis inclination and Scrub radius. What are the effects of each on the steering characteristics of a vehicle?

Ans. Camber :

Camber is the tilt of the car wheels from the vertical. Camber is positive if the tilt is outward at the top. Camber is also called 'wheel rake.'

Effect :

It is always desirable that tyres should roll on the ground vertically so that the wear is uniform. If while running, the tyres are inclined from the vertical either increased or outward, they will wear more on one side than the other. It is seen that because of this positive camber, the rolling radius at different points of the tyre thread is different as a result of which the tyre tends to roll like a truncated cone about centre of rotation O. In same manner, a negative camber will cause the front wheels to toe-in & wear more on the insides. Initial positive camber is provided to the wheels so that when the vehicle is loaded, they automatically come to a vertical position.

Castor :

The angle between the king pin centre line & vertical, in the plane of the wheel is called the castor angle. If the king pin centre line meets the ground at a point ahead of the vertical wheel centre line, it is called positive castor while if it is behind the vertical wheel centre line, it is called negative castor.

It can be visualised easily that in a vehicle with positive castor on front wheels, the body is lifted up as the front wheels toe-out and it is lowered when these toe-in. The positive castor in the wheels, therefore, results in a natural tendency in the wheels to toe-in. The negative castor would have the opposite effect, i.e., the wheels will tend to toe-out.

In case both wheels have the same positive castor, both will have equal tendencies toe-in, which will be balanced by each other, because track rod is provided to maintain the distance between the wheels rigidly. However, if the castor at the two wheels is not equal, the tendency to toe-in at the wheel with larger castor will be more which will cause the vehicle to pull constantly towards the side of the wheel with lesser castor.

Steering Axis Inclination :

It is defined as the inclination of the ball joint-axis from the vertical. Steering axis is an imaginary line drawn through the lower and upper steering pivot points. SAI is non-adjustable, since it would change only if the wheel spindle or steering knuckle are bent.

Effect :

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. So, as soon as the steering wheel is left after the turn is completed, the weight of the vehicle tends to return the wheels to the straight ahead position.

Amount :

About 7 to 8 degrees. However, the exact amount is decided by considering the wheel rake value.

Scrub Radius :

In a rear-wheel drive vehicle, the tractive force of the vehicle pushes the suspension cross-member and the body forwards during drive. Thus, the forward tractive force acts at the point on the road where the steering axis or the king pin axis meets when projected. The road resistance acts at the wheel contact point on the road. The distance between these two points is called scrub radius. It is positive when the tyre centre line lies outside the steering axis. It is negative when the tyre centre line is inside the steering axis. It is measured in mm. The amount of the scrub radius depends upon the steering axis indication, the wheel offset and suspension height. In front wheel drive, the tractive force is imported to the front wheels so that it acts forward through the wheel contact point on the road. Thus, the effect is opposite in nature to that in the rear-wheel drive.

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

Ans. Disc Brakes :

A disc brake consists of a cast-iron disc bolted to the wheel hub and a stationary housing called caliper. The caliper is connected to some stationary part of the vehicle, like the axle casing or the stub axle and is cast in two parts, each part containing a piston. In between each piston and the disc, there is a friction pad held in position by retaining pins, spring plates, etc. Passages are drilled in the caliper for the fluid to enter or leave each housing. These passages are also connected to another one for bleeding. Each cylinder contains a rubber sealed ring between the cylinder and the piston.

When the brakes are applied, hydraulically actuated pistons move the friction pads into contact with the disc, applying equal & opposite forces on the later.

On releasing the brakes, the rubber sealing rings act as return springs and retract the pistons and the friction pads away from the disc. For a brake of this type,

$$T = 2\mu paR$$

Where, μ = Coefficient of friction.

P = Fluid pressure

a = Cross-sectional area of one piston.

R = Distance of the longitudinal axis of the piston from the wheel axis.

Comparison of Disc and Drum Type of Brakes :

1. In case of disc brakes friction surfaces are directly exposed to the cooling air, whereas in the drum type, the friction occurs on the internal surfaces, from which heat can be dissipated only after it has passed by conduction through the drum.
2. Compared to the drum type, the disc brakes are simple in design. There are very small number of parts to wear or not function properly.
3. It is very easy to replace the friction pads when required, compared to the drum type where the brake linings have to be either riveted or fixed with adhesives to the brake shoes.

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

Ans. Cross ply Type :

In this type, the ply cards are moves at an angle (30° – 40°) to the tyre axis. There are two layers which run in opposite directions.

However, the cards are not waven like wrap and left of ordinary cloth, because that would lead to rubbing of the two layers and thus, produce heat which would damage the tyre material.

Radial ply type :

In this the ply cards, hum in the radial direction i.e., in the direction of the tyre axis. Over this basic structure, run a number of breaker strips in the circumferential direction. The material for the breaker strips must be flexible but inextensible, so that no change of circumference takes place with change in the amount of inflation. Without the breaker strips, radial plies would give very soft side, but there will not be any lateral

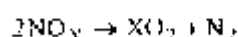
stability. The inextensible breaker strip behaves like a girder in its own plane, and provide the directional stability.

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

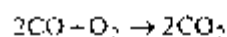
Ans. A catalytic converter is a device used to reduce the toxicity of emissions from an internal combustion engine. A catalytic converter provides an environment for a chemical reaction where in toxic combustion by products are converted to less-toxic substances.

Three way catalytic converter : A 3-way catalytic converter has three simultaneous tasks :

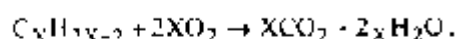
1. Reduction of nitrogen oxides to nitrogen and oxygen :



2. Oxidation of carbon monoxide to carbon dioxides



3. Oxidation of unburnt hydrocarbons to CO_2 & H_2O



Q. 8. (b) What are the sources of atmospheric pollution from the automobile? Discuss the pollution control techniques used in practice.

Ans. Capturing Vented Vapours :

Within the vehicle, vapours from the fuel tank are channelled through canisters containing activated carbon instead of being vented to the atmosphere. These are known as carbon canisters. The vapours are absorbed within the canister, which feeds into the inlet manifold of the engine.

Exhaust Gas Recirculation :

Many engines produced after 1973 model year have an exhaust gas recirculation valve between the

exhaust and intake manifolds, its role purpose is to reduce NO_x emission by introducing metered and quite small amount of inert gas into the air/fuel mixture, lowering peak combustion temperatures. In the case of EGR, the exhaust gases are inert enough to serve this purpose.

Catalytic Converters :

It is a device, placed in the exhaust pipe, which converts various emissions into less harmful over using, generally, a combination of platinum, palladium and rhodium as catalysts. They make for a significant and easily applied, method for reducing tail pipe emissions. Catalytic converters are damaged when used on engines that known leaded fuels. Unleaded files were marketed in 1973 & by 1996 leaded fuels were banned completely for on-road use in the USA.