

B.E.

Seventh Semester Examination, Dec-2007

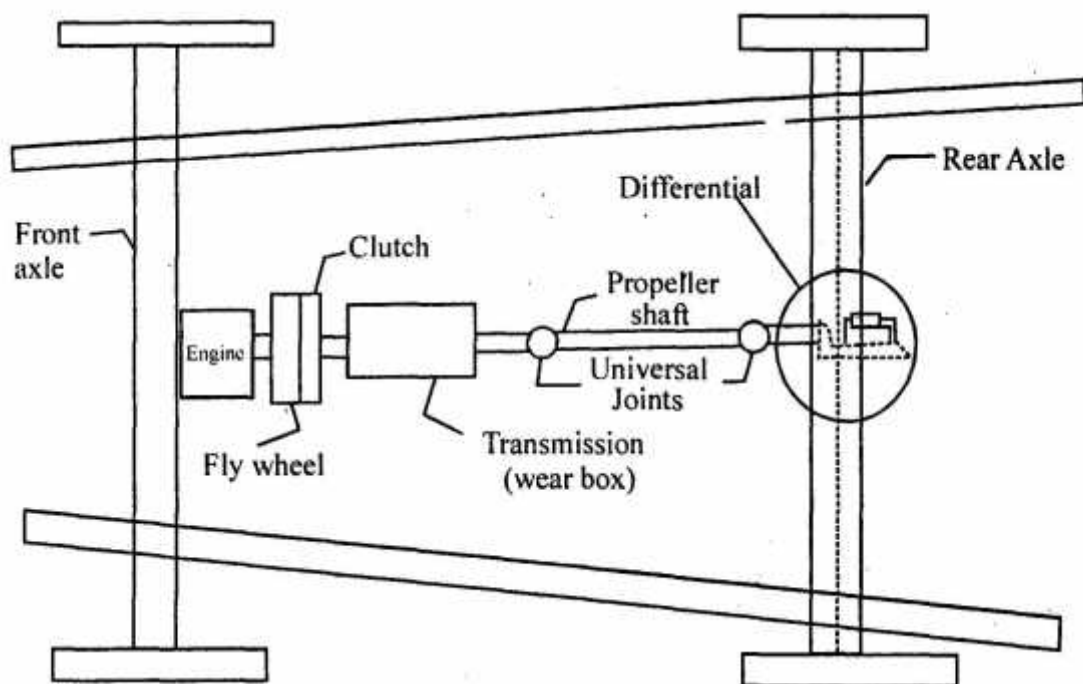
AUTOMOBILE ENGINEERING

Note : Attempt any five questions.

Q. 1. (a) Give a neat sketch of a motor vehicle chassis having "Front Engine Rear Drive" and name all the components.

State merits and demerits of such a system.

Ans.



Functions of the frame :

1. To support the chassis components and the body.
2. To withstand static and dynamic loads without undue deflection or distortion.

Loads on the frame :

1. Weight of the vehicle and passengers, which causes vertical bending of the side members.

2. Vertical loads when the vehicle comes across a lump or hollow, which results in longitudinal torsion due to one wheel lifted (or laboured) with other wheels at the usual road level.
3. Loads due to road camber, side wind, cornering free while taking a turn, which result in lateral bending of side members.
4. Load due to wheel impact with road obstacles may cause that particular wheel to remain deformed while the other wheel tends to move forward, distorting the frame to parallelogram shape.
5. Engine torque and braking torque tending to bend the side members in the vertical plane.
6. Sudden impact loads during a collision, which may, result in a total collapse.

Q. 1. (b) Explain briefly the construction features of the various parts of a car body.

Ans. Normally the various components are tested directly to the main frame. But many a time, these components are mounted on a separate frame called sub-frame. This sub-frame is further supported by the main frame at three points. In this way the components are isolated from the effects of twisting and flexing of the main frame. The advantages of sub-frames are :

1. The mass of the sub-frame alone helps to damp vibrations.
2. The provision of sub-frame simplifies production on the assembly line and facilitates subsequent overhaul or repair.

Frameless construction :

In this type of construction heavy side members used in conventional construction are eliminated and the floor is strengthened by cross-members and the body, all welded together. In some cases the sub-frames are also used along with this type of construction.

Vehicle dimensions :

Two important dimensions used to describe the size of an automobile of the framed or the frameless type are :

(i) Wheel track :

This is the transverse distance between the tyre to ground centres on the near-side and the off-side.

(ii) Wheel base :

This is the longitudinal distance between the centres of the front and the rear axles.

Q. 2. (a) What is the function of a clutch in an automobile? Explain the principle of friction clutches with the help of neat diagrams.

Ans. Function of clutch :

1. Torque transmission :

The clutch should be able to transmit the maximum torque of the engine under all conditions. It is usually designed to transmit 125 to 150 percent of the maximum engine torque. As the clutch slips during engagement, the clutch facing is heated. Clutch temperature is the major factor limiting the clutch capacity.

2. Gradual engagement :

The clutch should positively take the drive gradually without the occurrence of sudden jerks.

3. Heat dissipation :

During clutch application, large amounts of heat are generated. The rubbing surfaces should have sufficient area and mass to absorb the heat generated. The proper design of the clutch should ensure proper ventilation or cooling for adequate dissipation of the heat.

4. Dynamic Balancing :

This is necessary particularly in the high speed clutches.

5. Vibration damping :

Suitable mechanism should be incorporated within the clutch, to eliminate noise produced in the transmission.

6. Size :

The size of the clutch must be smallest possible so that it should occupy minimum amount of space.

7. Inertia :

The clutch rotating parts should have minimum inertia. Otherwise, when the clutch is rebased per gear changing, the clutch plate will keep on spinning, causing hard shifting and gear clashing in spite of synchronizers.

8. Clutch free pedal play :

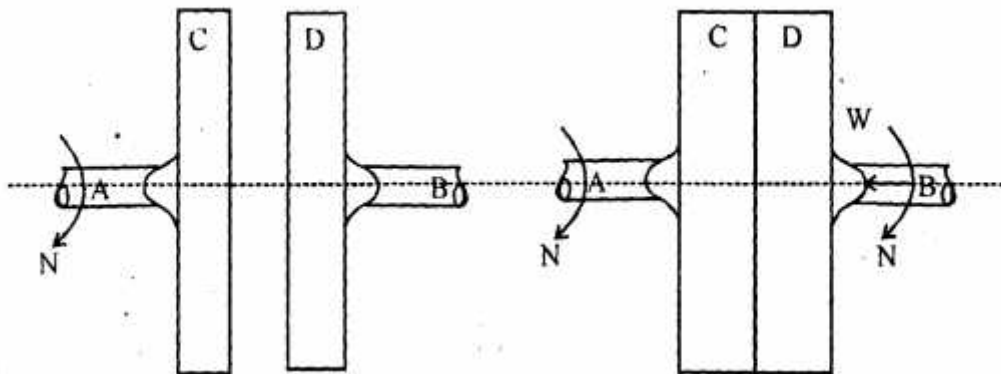
To reduce effective clamping load on the carbon thrust bearing and wear thereof, sufficient clutch free pedal play must be provided in the clutch.

Ease of operation :

For higher torque transmissions the operation of disengaging the clutch must not be tiresome of the driver.

Principle of friction clutches :

Let shaft A and disc C be revolving at some speed, say N r.p.m. Shaft B and the disc D keyed to it are stationary, initially when the clutch is not engaged. Now apply some axial force W to the disc D so that it comes in contact with disc C. As soon as the contact is made the force of friction between C and D will come into play and consequently the disc D will also start revolving. The speed of D depends upon friction force present, which in turn, is proportional to the force W applied. If W is increased gradually, the speed of D will be increased correspondingly till the stage comes when the speed of D becomes equal to the speed of C. Then the clutch is said to be fully engaged.



Principle of friction clutch

Let W = Axial load applied

μ = Coefficient of friction

T = Torque transmitted

R = Effective mean radius of friction surface

The expression for the torque for different types of clutches have been derived at appropriate places in this chapter.

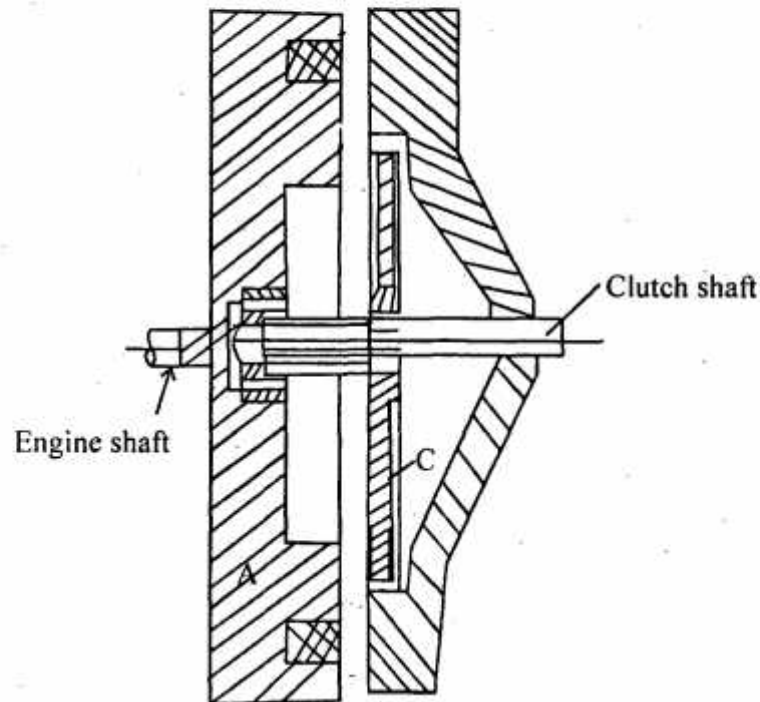
Then $T = \mu WR$

Thus, we see that the torque transmitted by a friction clutch depends upon three factors, i.e., μ , W and R . This means that increasing any or all of the above factors would increase the amount of torque which a clutch can transmit.

Q. 2. (b) Discuss the construction and working of an Electromagnetic clutch with a neat diagram.

Ans. Electromagnetic operation :

This type of clutch has been employed on some penult cars. The construction and working of this clutch may be understood by means of simplified figure shown below :



A is the engine flywheel incorporating the winding B. Clutch plate C is lined with friction surfaces and is free to slide on splines on the clutch shaft. D is the pressure plate. The winding B is supplied with current from battery dynamo.

When the winding B is energized, it attracts the pressure plate D, thereby engaging the clutch. When supply to winding B is cut-off, the clutch is disengaging.

There is a clutch release switch in the gear lever. This switch is operated as soon as the driver holds the gear lever to change the gear, cutting off current to the winding and thus causing clutch disengagement ordinarily the winding is connected to engine dynamo. At lower engine speeds, dynamo output is also low which makes the pressure of winding very small. Three springs are also provided in the clutch to balance this reduced electromagnetic pressure at low speeds, thus disengaging the clutch.

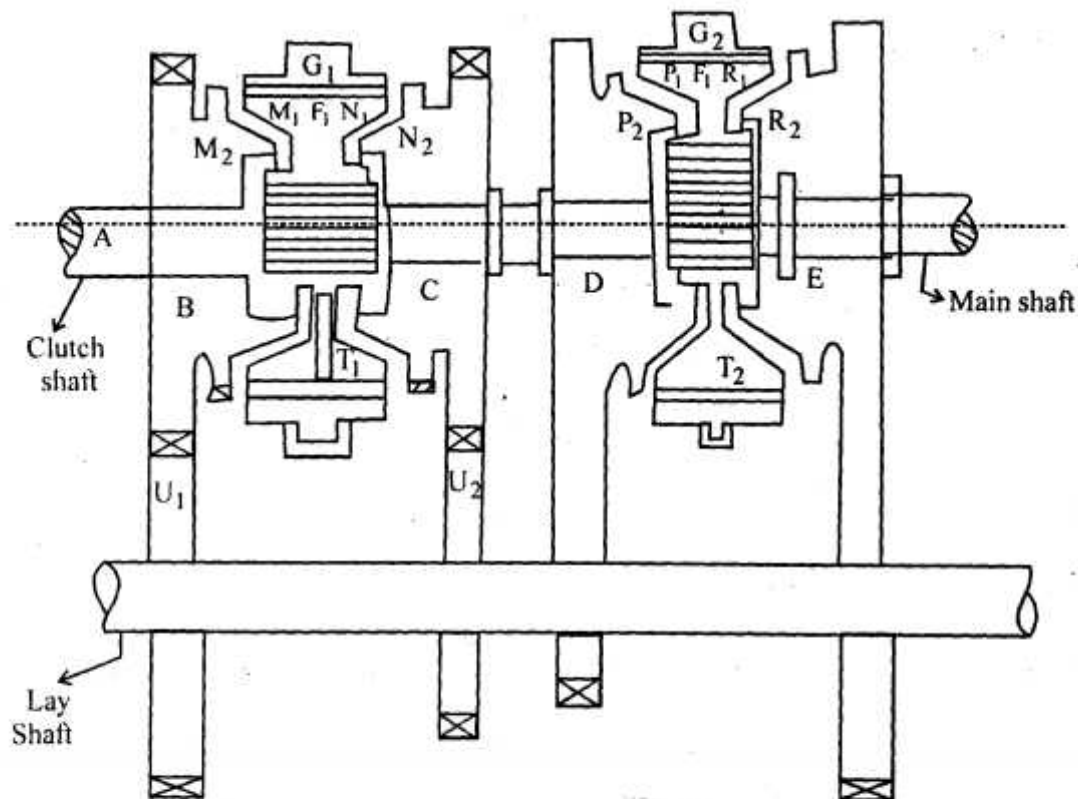
During normal operation, the electromagnetic force of the winding is regulated by means of an electrical resistance, which itself is controlled by means of accelerator pedal. As the accelerator pedal is pressed the

resistance is gradually cut, thus increasing the electromagnetic price.

The electromagnetic type of clutch is least suited where remote operation is derived since no linkages are required to control its engagement. A major limitation of this type is that of heat capacity since the clutch-operating temperature is limited by the temperature of the insulation of the magnetic coil. Another disadvantage is its higher initial cost.

Q. 3. Explain the working of a synchromesh gearbox with the help of a neat sketch. Why is a synchronizer ring sometimes used in these gear boxes? Discuss its merits and demerits compared to sliding mesh or constant mesh types of gear boxes.

Ans. Synchromesh Gear Box :



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 equalizes their speed, after which these may be engaged smoothly. Fig. shows the construction and working of the synchromesh gear box. In most of the cars, however, the synchromesh device are not fitted to all the gears as is shown in fig. They are fitted only on the high gears and on the low and leverage gears ordinary dog clutches are only provided. This is done to reduce the constant. In fig. A is the engine shaft, gears B, C, D, E are free on the main shaft and are always in mesh with corresponding gears on the layshaft. Thus all the gears on mainshaft as well as on layshaft continue to rotate as long as shaft A is rotating. Members F_1 and F_2 are free to slide on splines on the mainshaft. G_1 and G_2 are ring shaped members having internal teeth fit onto the external teeth members F_1 and F_2 respectively. K_1 and K_2 are dog that on B and D respectively and these also fit onto the teeth of G_1 and G_2 . S_1 and S_2 are the forks. T_1 and T_2 are the balls supported by springs. There are usually six of these balls symmetrically placed circumferentially in on synchromesh device. $M_1, M_2, N_1, N_2, P_1, P_2, R_1, R_2$ are frictional surfaces.

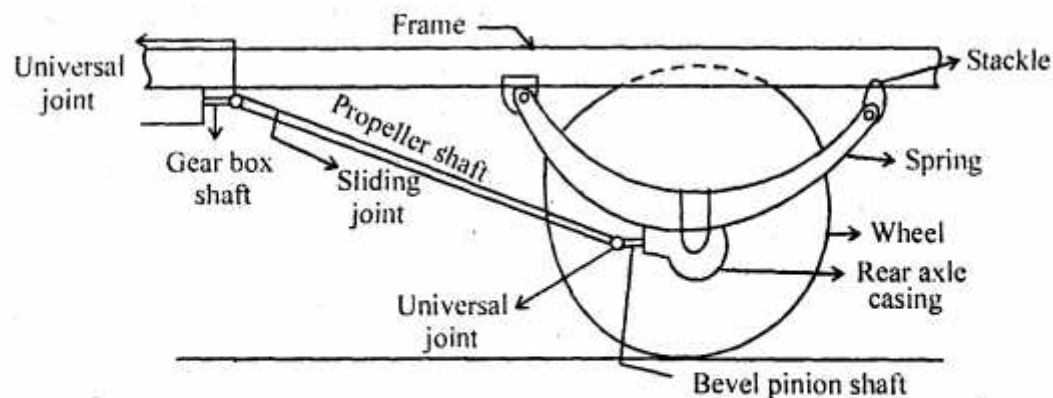
Q. 4. (a) Discuss in detail the two types of rear axle drives.

Ans. Two type of rear axle drives :

- (i) Hotchkiss drive
- (ii) Torque tube drive

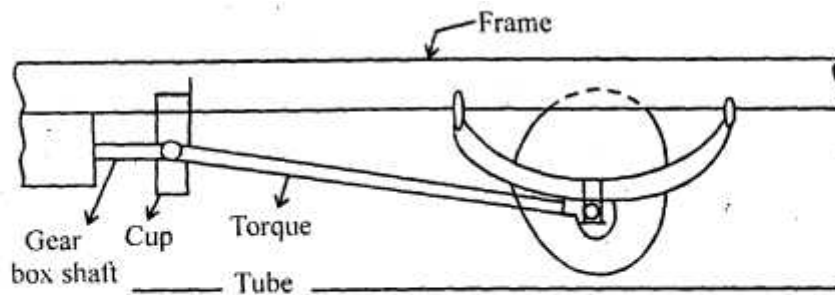
(i) Hotchkiss drive :

This is the simplest and most widely used type of rear axle 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 joint and also a sliding joint.



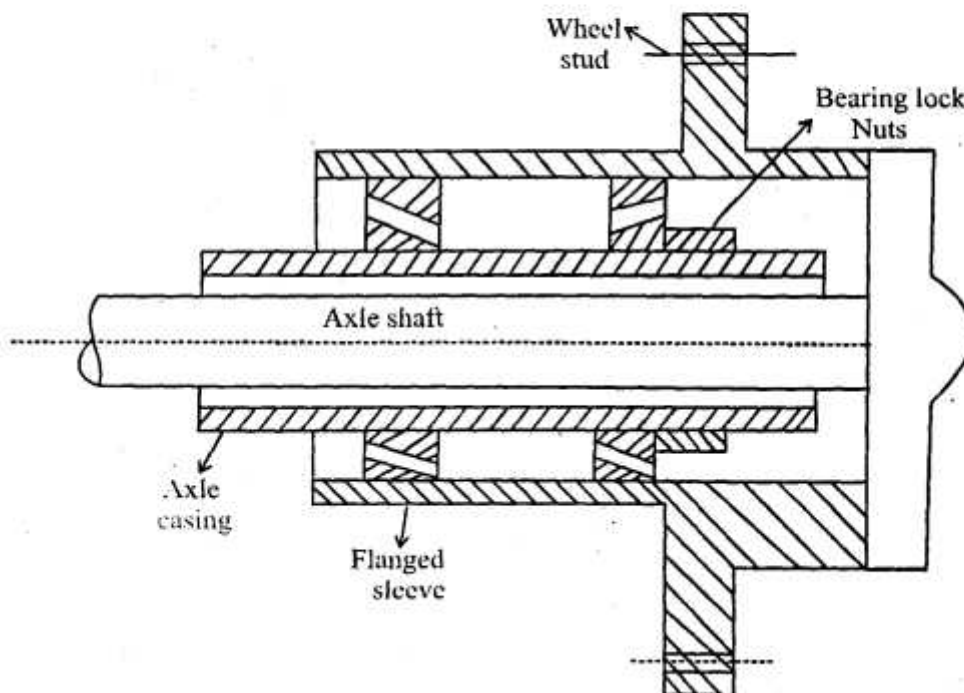
(ii) Torque tube drive :

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 fits in the cup fixed to the frame.



Q. 4. (b) In what type of vehicles fully-floating type of live rear axle is used? Describe in detail the construction of the same and discuss how various loads are taken by it.

Ans. Fully-floating type of rear axle : This type is very robust one and is used for heavy vehicles. As is seen in fig., the axle shaft have flanges at the outer ends, which are connected to the flanged sleeve by means of bolts. There are two taper roller bearing supporting the axle casing in the hub, which take up any side load. Thus, in this the axle shafts carry only the driving torque. The weight of the vehicle and the end thrust are not carried by them, the weight being completely supported by the wheels and the axle casing. As the axle shafts carry only the driving torque, their failure or removal does not affect the wheels. Thus, the axle shafts can be taken out or replaced without jacking up the vehicle. For the same reason the vehicle can be towed with a broken half-shaft. However, it is the costliest type.



Q. 5. (a) Discuss in detail the objects of an automobile suspension.

Ans. Objects of automobile suspension :

The automobile chassis is mounted on the axles, not direct but through some form of springs. This is done to isolate the vehicle body from the end of road shocks which may be in the form of bounce, pitch, roll or sway. These tendencies give rise to an uncomfortable ride and also cause additional stress in the automobile frame and body. All the parts which perform the function of isolating the automobile from the road shocks are collectively called a suspension system.

Broadly speaking, suspension system consists of a spring and a damper. The energy of road shock causes the spring to oscillate. These oscillations are restricted to a reasonable level by the damper, which is more commonly called a shock absorbers.

Objects of suspension :

1. To prevent the road shocks from being transmitted to the vehicle components.
2. To safeguard the occupants from road shocks.
3. To preserve the stability of the vehicle in pitching or rolling, while of motion.

Q. 5. (b) What is independent suspension? Explain various methods to achieve the same in front axles of cars.

Ans. Independent suspension :

When a vehicle with rigid axle suspension encounters road irregularities, the axle tits 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. Besides, the independent suspension also has the following advantages over the rigid axle type suspension :

1. Elastic strain energy per unit spring weight stored in a coil 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 type scribal and hence increases type life.
3. Compared to the rigid axle type, softer, springs can be used without increasing rolling effect.
4. In case of independent suspension it is possible to locate the springs apart enough to obtain under-steer conditions.

Five types of independent suspension are in use for front axle.

1. Wishbone type or parallel link type.
2. Mac pherson struct type
3. Vertical guide type
4. Trailing link type
5. Swimming half-axle type.

Q. 6. (a) Give a neat layout of steering mechanism and name all the components. Explain briefly its operation.

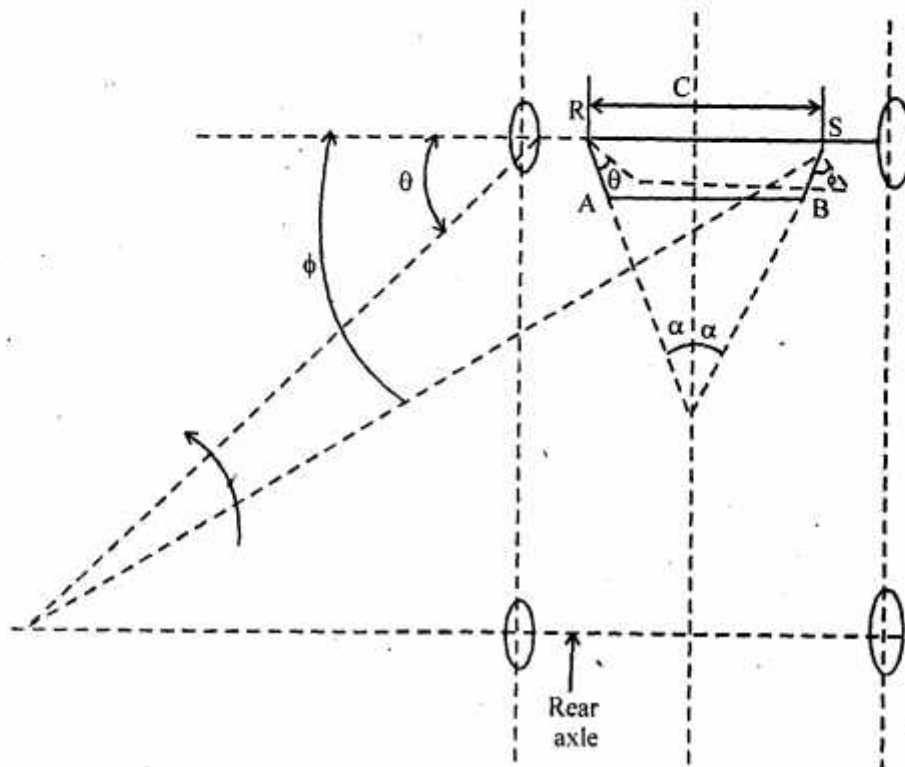
Ans. Steering mechanism : We have already seen that for perfect steering we must always have an instantaneous centre about which all the wheels must rotate. For this purpose inner wheel has to turn more than the outer wheel. To achieve this condition, two types of mechanisms, have been devised, viz., the Davis and the Ackermann steering mechanisms. Out of these Ackermann mechanism is almost universally used because of its simplicity. Ackermann mechanism,

Let l = length of track rod.

r = length of links RA and SB.

Then
$$\sin(\alpha + \beta) = \frac{y + x}{r}$$

&
$$\sin(\alpha - \psi) = \frac{y - x}{r}$$



On adding, we get

$$\sin(\alpha + \theta) + \sin(\alpha - \psi) = \frac{2y}{r} = 2 \sin \alpha$$

The mechanism gives only 3 positions for correct steering, one wheel $P = 0$ and the other when corresponding to the turn to right or left.

Q. 6. (b) Describe "Power Steering" and state its merits and demerits.

Ans. Power steering :

The power system is designed to become operative when the effort at wheel exceeds a predetermined value, say 10N. The system is always so designed that in the event of the failure of the power system, the driver is able to steer the vehicle manually although with increased effort. The power steering systems are operated by fluid under pressure. The fluid usually used are oils of viscosity rating SAE 5W or SAE 10 W or higher depending upon the atmospheric conditions.

Merits of power steering are :

1. No problem of leakage of fluid.
2. Energy being consumed only while steering.
3. Steering assistance available even when the engine is not receiving.
4. While steering manually lesser force is required compared to a hydraulic system since there is no fluid to be forced through valves.

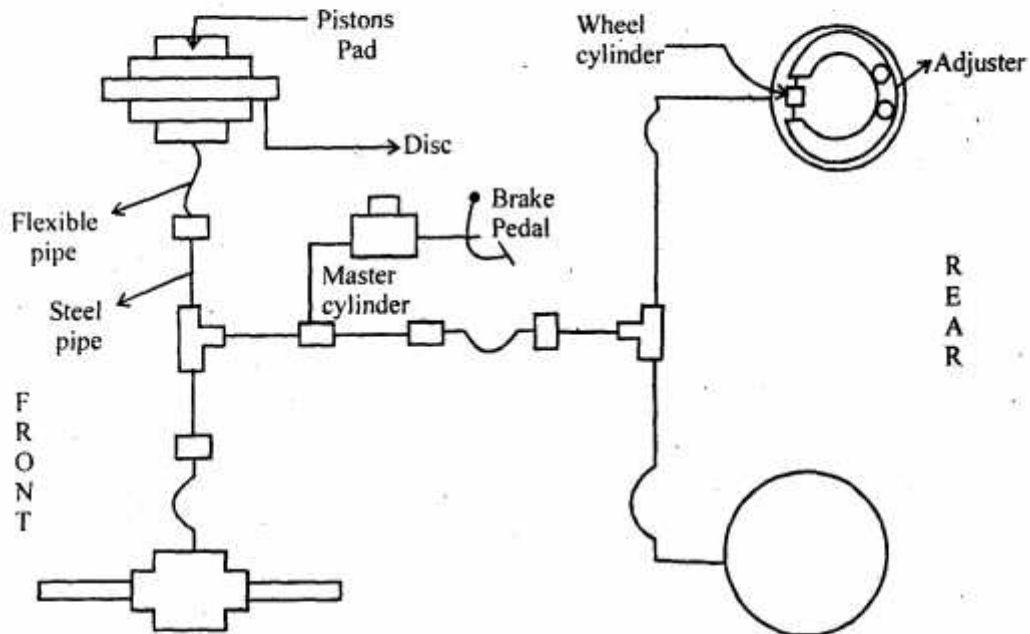
Q. 7. (a) What is the principle of operation of hydraulic brakes? Discuss the main parts of hydraulic brakes.

Ans. Hydraulic Brakes :

Most of the cars today use hydraulically operated foot brakes on all the four wheels with an additional hand brake mechanically operated on the rear wheels. An outline of the hydraulic braking system is shown in fig. The main component in this is the master cylinder, which contains reservoir for the brake fluid. Master cylinder is operated by the brake pedal and is further connected to the wheel cylinder in each wheel through steel pipe lines, unions and flexible hoses. In case of Hindustan Ambassador car on front wheels each brake shoe is operated by separate wheel cylinder, whereas in case of rear wheels there is only one cylinder on each wheel which operates both the shoes.

As the rear wheel cylinders are also operated mechanically with the hand brake, they are made floating.

Further all the shoes in the Ambassador car are of the floating type. The system is so designed that even when the brakes are in the released position, a small pressure of about 50 kPa is maintained in the pipe lines to ensure that the ups of the wheel cylinder are kept constant.



Hydraulic brake system

Q. 7. (b) Write down the advantages and disadvantages of hydraulic brakes over mechanical brakes.

Ans. Advantages of hydraulic brakes over mechanical brakes are :

1. As the rear wheel cylinders are also operated mechanically with the hand brake, they are made floating.
2. The system is so designed that even when the brakes are in the released position.
3. These keeps the free travel of the pedal minimum by opposing the brake shoe retraction spring.

Disadvantages of hydraulic breaks over mechanical brakes are :

1. There are a number of holes in the piston head on the primary seal side.
2. During bleeding, it does not allow the fluid pumped into the line to return, thus quickly purging air from the system.
3. As the pedal is pressed, push rod moves the piston to left against the force of the spring, till it covers the by-pass port.

Q. 7. (c) Compare the disc and drum types of brakes.

Ans. Compare the 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.
2. The friction pads in the case of disc brakes are flat as compared to curved friction lining in case of drum brakes.
3. Unlike the conventional drum brake, the design of disk brake is such that there is no loss efficiency due to expansion.
4. Disc brakes weigh less than their conventional drum type counterpart a saving of approximately 20 percent being possible.
5. 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.

Q. 8. (a) What are the pollutants emitted by an? Explain construction and operation of positive crank case ventilation system.

Ans. Pollutants emitted by automobiles : The pollutants produced by automobiles are created by the burning or evaporation of the automobile's fuel. These can be divided into three main substances : CO, HC and NO_x . These gases are unpleasant to breathe and are in many cases harmful or even dangerous to human being, animals or plants.

A hydrocarbon is a substance consisting of atoms of hydrogen (H) and carbon (C) jointed together into various combinations called molecules. There are many different types of hydrocarbons used as fuel, but the type most commonly used in automobiles is gasoline, which is a mixture of several different types of hydrocarbons, the most predominating type is most mixtures being the one called octane.

1. Exhaust Gas : When gasoline burns, it combines with the oxygen in the air to form carbon dioxide and water. This oxidation reaction can be expressed as follows :

Carbon monoxide : CO is produced by incomplete combustion of the gasoline, which is in turn caused by a lack of sufficient oxygen at the time of combustion.

Hydrocarbon : HC is raw unburnt gasoline emitted from the automobiles.

Oxides of Nitrogen : NO_x is produced by the nitrogen and oxygen in the air of the air-fuel mixture. Which combine if the temperature inside the combustion chamber rises above $1,800^\circ\text{C}$.

Positive crank case ventilation (PVC) : From 70 to 80% of the blow by gases present in the crankcase in unburnt gas, while the by product of combustion make up the remaining 20 to 30%. All of these can be breakdown the engine oil, creating sludge or cause corrosion and rusting of the crankcase. To prevent this, vehicles built up until recently were equipped with an air tube leading from the crankcase to allow these gases to escape into the atmosphere. However, since this is not permitted under many recently-enacted clean air laws, these blow-by gases must be returned to the combustion chamber for reburning.

Q. 8. (b) Discuss purpose and operation of starting system used in automobile.

Ans. Ignition system : In principle, a conventional ignition system should provide sufficiently large voltage across the spark plug electrodes to effect the spark discharge. Further, it should supply the required energy for the spark to ignite the combustion mixture adjacent to the plug electrodes under all operating conditions. It may be noted that for a given engine design, the optimum spark timing varies with engine speed, inlet manifold pressure and mixture composition. The design of a conventional ignition system should take these factors into account to provide the sparks of proper energy and duration at the appropriate time.

As air is a poor conductor of electricity an air gap in an electric circuit acts as a high resistance. But when a high voltage is applied across the electrodes of a spark plug it produces a spark across the gap. When such a spark is produced to ignite, a homogeneous air-fuel mixture in the combustion chamber of an engine, it is called spark-ignition system. The ignition systems are classified depending upon how the primary energy for operating the circuit is made available as :

- (i) Battery ignition systems.
- (ii) Magnate ignition systems.

Requirements of an ignition system : A smooth and reliable functioning of an ignition system is essential for reliable working of an engine. The requirements of such an ignition system are :

- (i) It should provide a good spark between the electrodes of the plugs at the correct timing.
- (ii) It should function efficiently over the entire range of engine speed.
- (iii) It should be light, effective and reliable in service.
- (iv) It should be compact and easy to maintain.
- (v) It should be cheap and convenient to handle.
- (vi) The interference from the high voltage should not affect the functioning of the radio and television inside an automobile.