1. What are the basic units in vehicle classis?

   1. Basic structure
   2. Transmission unit
   3. Electrical systems
   4. Body or substructure
   5. Power unit
   6. Control and instructions

2. What are the functions of the frame?

   a. To carry the weight of the vehicle and passengers.
   b. To withstand the engine and transmission torque.
   c. To bear thrust, acceleration and braking torque.
   d. To withstand bending and twist.
   e. To provide correct spacing between different components.
   f. To bear the suspension system.

3. What are the types of frame?

   1. Conventional frame
   2. Semi integral frame.
   3. Integral frame.
4. Classified the engine by value arrangement?

   a. ‘L’ Head engine 
   b. ‘I’ Head engine. 
   c. ‘F’ Head engine 
   d. ‘T’ Head engine 

5. Why is cylinder head cast as a separate piece?

   Cylinder head is cast as a separate piece for easy removal, for cleaning and grinding valves to provide provision conventionally for spark plug, injector for flow of water etc.

6. What is the purpose of Gasket?

   Gasket are used to makes a good seal to provide a tight joint between the cylinder block and head to with stand heat and pressure losses.

7. What are the functions of piston?

   1. The piston receivers the thrust produced by combustion and transmits the power to the connecting rod. 
   2. It reciprocates to cause different strokes. 
   3. It acts as bearing to the small end of the connecting rod and bears side thrust.

8. What are the functions of piston rings?

   1. Prevention of leakage of gas into the crank case. 
   3. Prevention of lubricant entry into the combustion chamber above the piston head. 
   4. Removing unnecessary and excessive lubricating oil from cylinder wall 
   5. Prevention of carbon deposits and other impurities on the piston head.
6. Easy transmission of heat from piston to cylinder wall.

9. Why are piston pin made hollow?

To reduce the inertia load due to reciprocating parts.

10. What are the troubles possible by excessive clearance between intake valve and stem?

When there is too much clearance between valve stem and guide, fuel will be inducted, leading to excessive fuel consumption. Engine deposits, pre ignition, clogged piston ring, fould spark plug, damaged valve seat are other troubles.

11. What is interference angle in valve?

The valve is faced at an angle ¼ to one degree flatter than that of the seat angle. This is known as interference angle.

12. What is the purpose of flywheel?

Fly wheel is an energy reservoir to assist the engine the idle smoothing when the power is not being produced and also minimize the fluctuation of mean speed.

Fly wheel stores the excess energy in power stroke and helps back in compression stroke maintaining uniform speed.


According to speed

# Low speed engine
# High speed engine
According to fuel used:

- Petrol Engine
- Diesel Engine
- Gas Engine

According to methods of Cooling:

- Air cooling engine
- Water cooling engine
- Evaporation cooling engine

14. What are the materials used for cylinder block and piston:

Cylinder block : Grey cast Iron, aluminium alloy
Piston : Aluminium alloy with coppers Nichol and silicon.

15. What are the materials used for connecting rod and crank shaft?

Connecting rod : Forged alloy steel, Nichel chromium steel.
Crank shaft : Heat treated alloy steel, Nitride steel.

16. What are the materials used for camshaft and fly wheel?

Cam shaft : Grey Iron, Alloy Steel, case hardened steel.
Fly wheel : Hardened steel, High grade castings.

17. State a main advantages of 2 stroke engine over 4 stroke engine.
1. 2 stroke engine gives one working stroke for each revolution of the crank shaft. 4- stroke engine gives one working stroke for every two resolutions of the crank shaft.
2. The power developed by two stroke engine is twice that developed by 4-stroke engine for the same engine speed and cylinder volume (theoretically).

18. What are the basic operations in engine?

1. Suction stove
2. Compression stoke
3. Power stroke
4. Exhaust stroke

19. State any two advantages of gas turbine?

1. Gas turbine is smooth in operations and continuous in performance.
2. Does not have any reciprocating part, hence it is easy to balance. It is free from vibrations.

20. State any two disadvantages of Gas turbine?

1. Due to very high speed, the gas turbine causes serious problem in obtaining as effective transmission speed suitable for road speeds.
2. Braking is not effective due to very high speed.

21. What is firing order?

The sequent in which the power impulses occur in an engine is called the firing order.

22. Given firing order of four cylinder and six cylinder engine.

Four cylinder engine: 1-2-4-3
6 cylinder engine: 1-4-2-6-3-5
1-5-3-6-2-4

23. What are the types of cooling?

1. Water cooling system
2. Air cooling system

24. Classification of water cooling systems.

1. Thermo siphon system
2. Impeller thermo siphon system
3. Pump circulation system.

25. What are the main components of pump circulating system?

1. Radiator
2. Pressure cap.
3. Form and belt
4. Water jacket in cylinder block
5. Thermostat
6. Hoses
7. Water pump
8. Water

26. What is the purpose of radiator?

Radiator is filtered in front of use engine, main purpose of radiator is to radiate heat in the water through air current passing around its tube. Radiator is made up of following parts.
1. Upper tank  
2. Radiator core  
3. Lower tank  

27. What is air cooling system?  

In this system, air is made to come in contact with cylinder block and head, this cool air takes away excessive heat. Fins are made on cylinder and block for better contact with cool air. It occupies less space, mostly used in two wheelers and three wheelers.

28. How to maintain the air cooled engine?  

1. keep fins of cylinder and cylinder head always clean from dust.  
2. keep me air duct properly aligned and clean.  
3. keep me blower belt properly tensioned.

29. Mention the advantages of water cooling system?  

1. As water is in direct touch with cylinder walls and head, it takes away heat quickly.  
2. The water circulates freely between freezing and boiling points.  
3. The presence of water in water jackets damps down sound of engine to some extent.  
4. Engine working temperature can be controlled easily.

30. What are the disadvantages of water cooled system?  

1. In water cooled system, weight of radiator with water pump etc increases dead weight of the vehicle.  
2. Radiator is usually fitted in front of the vehicle. Due to its presence in front, slope on both net cannot be given to avoid wind resistance.  
3. Water freezes at zero degree temperature  
4. water boils and evaporates early at 100°C  
5. Water corrodes the metal part in no system.
31. What are the advantages of lubrication?

1. It reduces wear of parts.
2. It focus away heat and brings it back to sump.
3. It seals the piston rings with cylinder wall.
4. It cleans the flushes the moving parts.

32. What are the parts to be lubricated in automobile engine?

1. Cylinder wall
2. Connecting rod bearings
3. crank shaft bearings.
And other moving parts.

33. What are the types of lubricating system?

1. Splash type lubricating system.
2. Dry sump lubricating system.
3. Pressure type lubricating system.
   a. Low pressure type lubricating system
   b. High pressure type lubricating system.

34. What are the sources of pollutant in automobile?

1. Fuel tank → Gasoline Vapour
2. Carburetor → Gasoline vapour
3. Crank caste → Unburnt air fuel mixture blown through the piston rings.
4. Tail pipe → unburnt gasoline, hydrocarbon, carbon
35. What are the main pollutants contributed by automobiles?

1. Carbon monoxide (CO)
2. Unburned Hydrocarbons (UBHC)
3. Oxides of Nitrogen (NOx)
4. Lead and other particulars emissions

36. How to control the automobile pollutants?

1. Periodic servicing of ignition and carburetor systems.
2. The installation of a fuel tank with a built in chamber to provide an assured thermal expansion volume for fuel.
3. Treatment of Exhaust gas.
4. Reduction of lead in gasoline.
5. Fuel modification.
6. Lower compression ration
7. Retrading ignition living.
8. Reduce at value over lap

37. What is catalytic converter?

This is used to control the harmful exhaust emission by converting into other forms of harmless gases and liquid. As catalysis are used for emission conversion is known as catalytic converter.

38. What are the types of catalytic converter?

1. Two way catalytic converter.
2. Three way catalytic converter.

39. What is the difference between two way and three way catalytic converter?
In two way converter only hydrocarbons and carbon monoxide are converted. Nitrogen oxide remains same. But in three way catalytic converter all the three are converted into carbon dioxide, nitrogen and water vapour.

PART – B

1) List the essential parts of a motor vehicle engine?

   a) Cylinder block
   b) Cylinder head
   c) Crank case
   d) Piston
   e) Piston rings
   f) Piston pin
   g) Connecting rod
   h) Crank shaft
   i) Flywheel
   j) Valves and valve mechanism
   k) Rocker arm
   l) Cam shaft
   m) Accessories: air cleaner, oil filter, automatic chokes, automatic heat controls
   n) Other parts: Spark plug, ignition devices, carburetor, manifolds, vibration damper

2) Describe the function of cylinder head gasket?

https://ourmechanicalengg.wordpress.com/
A gasket is placed between the cylinder head and cylinder head and cylinder block to retain compression in the cylinder to prevent leakage and to ensure metallic tight fit joint. The gasket should be able to withstand not only high pressure but also extreme temperature.

A typical gasket

Following important gaskets are used in automobile engines:

- a) Copper-asbestos gasket
- b) Steel-asbestos gasket
- c) Steel-asbestos-copper gasket
- d) Single steel ridged or corrugated gasket
- e) Stainless steel gasket

Often the gaskets are coated with a special varnish which melts and seals all the small interstices of the block and head when the engine warms up. Suitable holes are made in the gasket to pass the studs and for cylinder bore. Gaskets are also used to seal joints between other parts, such as between oil pan, manifolds, or water pump and the block.

Some of the gaskets produced by Fel-pro. Inc. of U.S.A. are as follows:

- a) Cylinder head gaskets: Metal sandwich type gasket is made of either copper and asbestos or steel and asbestos. It is mainly used on passenger cars and trucks.

Embossed steel or shim type gasket is generally used on I-head engine.
Shimbestos is a combination of thin steel heat shield on one side and high resilient specially treated metal reinforced asbestos on the top side.

Felbestos is made of perforated steel sandwiched between tow treated asbestos sheets.

b) **Oil pan gaskets:** are made of three different materials:

Cork has advantage of high compressibility but it is subject to shrinkage and expansion.

Felcoid is an improvement on cork. It is also highly compressible, but is less subject to shrinkage and expansion. It can withstand considerable bending and twisting without breakage.

Felcoprene is a synthetic rubber compound. It is highly resilient and compressible. It is not effected by oils and greases. It is not subject to expansion or shrinkage.

c) **Manifold gaskets:** are of three types-

Metal encased asbestos gasket is more resistant to burn out but is more expansive.

Felbestos is a perforated steel base with asbestos, mechanically bonded to one or both sides. Metal embossed shim gasket is also a good type of gasket for the manifolds.

d) **Pump gaskets:** are made of a number of material such as asbestos, karropak, felcoids, etc. They are treated to withstand oil, water, petrol and anti-freeze liquids. Karropak is a high quality vegetable fibre, while Felcoid is a combination of fibre and cork granules that is more compressible and resilient.

3) **Why flywheel is necessary in multi cylinder engine?**

A flywheel is a fairly heavy steel wheel attached to the rear end of the crank shaft. The size of the flywheel depends upon the number of cylinders and the general construction of the engine.
The flow of power from the engine cylinders is not smooth. Although the power impulses in a multi-cylinder engine overlap or follow each other to provide a fairly even flow of power, however, additional leveling off of power impulses is required. This is done by a flywheel.

To understand the function of a flywheel in a better way, take the example of a four-stroke, single cylinder engine. There are times when more power is being delivered than at other times. This tends to make the crankshaft speed up and then slow down. The engine delivers power during one stroke only the power stroke and it absorbs power during the other three strokes. To push out the exhaust-gases, to intake fresh charge in the cylinder and to compress this charge. Thus, during power stroke the engine tends to speed up and during the other three strokes it tends to slow down. The inertia of the flywheel tends to keep it running at constant speed. When the engine tends to speed up the flywheel resists it. When the engine tends to slow down, the flywheel resists it. Thus, the flywheel absorbs energy as the engine tries to speed up and gives back energy as the engine tries to slow down. Keeping the engine speed almost constant. In multi-cylinder engine, the flywheel acts in the same way to smooth out still more the peaks and valleys of power flow from the engine.

4) Describe the mechanism for operating a straight poppet valve?

Figure shows the valve mechanism to operate the valve when it is in the engine block. (in L, T and F-head designs). The valve stem slides up and down in the valve stem guide which acts as slipper bearing. It also prevents to gasses from passing from the valve port to the valve chamber of the engine block. Valve spring is fitted between the engine block and spring retainer. Which keeps the valve closed tightly on the valve seat, until lifted by the valve tappet by the rotation of the cam? The tappet (or) lifter is held between guide which is generally a part of the engine block. Adjusting screw is provided on the tappet to adjust the clearance between the upper end of the tappet and the bottom of the valve stem. As the cam rotates, it life the tappet which lifts the valve to the open position thus connecting the valve part to the combustion chamber.

Valve seat inserts are fitted on the valve seats. These inserts are in the form of rings tapered grounded to suit the valve faces and made of special alloy steels. Usually they are used only one exhaust valve seats. They reduce wear and can be replaced when worn out.

5. Describe the function of cylinder liner?

Cylinder liner:
The cylinder may wear out after frequent use. Hence the cylinders have to be replaced, but this is very costly. Therefore, instead of replacing the complete cylinder, it is better to fit a parallel sleeve in the block (just like a bush) this sleeve is known as cylinder liner (refer to the figures)

fig: a) Dry liner

These liners provide suitable wear resisting surfaces within the cylinders.

These are manufactured by centrifugal casting method.

cylinder lines are of two types,

1. Dry liner. 2. Wet liner.

**Dry liner:**

The dry liner is directly inserted in to the cylinder block. cooling water is not in contact with the liner. this type of liner s machined very accurately and pressed into the cylinder block. the outer surface of the liner rests against the cylinder block.
Fig: b) Wet liner

Wet liner:

In this case, cooling water is indirect contact with the surface of the liner. In this type, the liner is machined only on the inside and the outer surface is liner contact with water. There is a flange at the top of the liner acting as a shoulder by which it is fixed into the groove made in the cylinder block. At the bottom, synthetic rubber sealing rings are provided around the liner to prevent water leakage.

These types of liners are generally used in diesel engines. If the size of the piston and bore clearance exceed the standard limit both the liner and piston are to be replaced simultaneously. In case the cylinder bore exceeds the maximum size limit, the standard size of piston is fitted with installation of a new liner. These are thicker than dry liners.

6. Describe the function of piston and piston rings?

Piston:
The piston is the main active part of the engine. It has a close fit with the cylinder. The movement of the piston changes the volume in the cylinder and provides the combustion space. Generally, the pistons are made up of aluminum alloy. The aluminum alloy is the lightest one and has good heat conduction properties. A hole is centrally provided to insert a pin to connect the small end of the connecting rod. Circumferential grooves are provided on the surface of the piston.

Functions:

1. The piston receives the thrust produced by combustion and transmits the power to the connecting rod.
2. It reciprocates to cause different strokes.
3. It acts as bearing to the small end of the connecting rod and bears side thrust.
The piston diameter is slightly smaller than that of the cylinder. The gap between the piston and the cylinder wall is known as the piston clearance. This clearance is provided to avoid seizing of the piston in the cylinder. This clearance also provides the gap for a film of lubricant between the piston and the cylinder wall. A simple piston is shown in figure.

Piston rings:

These are made of special steel alloys which retain elastic properties at high temperature. These are circular rings fitted in the circumferential grooves of the piston. There are two sets of rings. Upper rings are known as compression rings which provide gas tight seal. This will prevent the leakage of the burnt gases into the casing. The lower rings are called oil scraper rings. These are provide to remove the oil film from the engine cylinder and prevent the leakage of oil into the cylinder. Refer figure.

Functions of piston rings:

1. Prevention of leakage of gas into the crank case.
2. Prevention of lubricating oil film
3. Prevention of lubricant entry into the combustion chamber above the piston head.
4. Removing unnecessary and excessive lubricating oil form cylinder wall.
5. Preventing of carbon deposits and other impurities on the piston head.
6. Easy transmission of heat from piston to cylinder wall
7. Describe the function of connecting rod?

This is the connecting link between the piston and the crank shaft, as shown in figure. By the oscillating movement of the connecting rod, reciprocating motion of the piston is converted into rotary motion of the crank shaft. The upper end of the connecting rod is called the small end, which carries the piston by means of a floating pin called piston pin or gudgeon pin as shown in figure. The lower end is called the big end of the connecting rod, which connects the crank shaft through a crank pin.
Fig: Connecting rod
8. Describe the function of timing Gears?

The timing gears are responsible for transmission between the crank shaft and the cam shaft. The transmission may be of gears or spockets and chain. As this transmission set timing of the engine, these are known as Timing Gears (as shown in figure). The opening and closing of the valves effected by the cam shaft operation are related to the movement of the piston which is caused by the rotation of the crank shaft. Their relationship can be adjusted properly by fixing the Crank and Timing Gears. This is known as Timing. Timing marks are provided on the gears to set the cam shafts in correct tie with each other, when both the cam and crank shafts are assembled. The timing is very important as the valves must open and close in proper sequence with respect to the piston position in the cylinder.
9. Explain the construction of valves?

Valves:

The valves are nothing but gates for opening and closing the inlet and exhaust passages in the cylinder. But this is a one way passage. Two valves are provided one for the inlet and the other for exhaust. Poppet and Mushroom valves are generally used in Automobile Engines. The simple construction is shown in figure.
The valve stem moves up and down, inside the passage called guide, which is fitted in the engine-block. The head of the valve, called as valve face is generally ground to have a 45 degree angle, so as to fit properly on the valve seat in the block and prevent leakage. A valve spring with a spring retainer aids the return of valve after operation. When the cam rotates, the tappet is lifted thereby lifting the valve to open. In the closed position of the valve a slight clearance is necessary between the valve tappet and the stem. This gap is known as valve tappet clearance. This gap allows for the expansion of the valve stem and other parts in the valve operating mechanism as the engine becomes heated. The clearance can also be adjusted with the help of a tappet adjusting screw or a lock nut so that the tappet clearance may be varied; thereby the opening and closing of the valve can be slightly adjusted. As the exhaust valve is exposed to exhaust gases, it needs more clearance than that of the inlet valve. In construction the valve seat and inserts are pressed into the cylinder block. These inserts reduce wear and tear preventing leakage and frequent replacing of valve or valve grindings.

10. Describe the valve operating mechanism?

Valve operating mechanism:

Side valve mechanism: This is shown in figure. The operation mainly depends upon the tappet adjustment. The mechanism has only few moving parts. The mechanism directly transmits motion to the valve stem. The opening of the valves are effected by lifting the valves off their seat.
Over Head Valve Mechanism: The valve operating mechanism in the over head valve requires two additional parts (1) push rod (2) Rocker Arm, as shown in figure. In this method, the valve is mounted over the head of the engine, and in opposite sides. Here the cam operates a valve tappet which pushes the push rod vertically. The push rod further operates the rocker arm which causes the valve to open against the retainer spring. (figure) opening o the valve is generally effected by moving the valve down. The rocker arm in multi-cylinders is provided on a common rock: arm Shaft. Valve tappet clearance which can be adjusted by means of an adjusting screw is provided between the rocker arm the valve stem.
11. Describe the function of inlet and Exhaust manifolds?

Manifolds:

The term manifold is applied to the external pipes or castings containing gas passages that connect the carburetor and the pipes to the inlet and outlet ports of the engine. In order to maintain maximum velocity of the gases, and to ensure the best possible breathing, it is obviously desirable that the passages should offer minimum resistance to gas flow.

The performance of a fresh engine depends upon a number of factors. Of course it is understood that the most important systems are: ignition, its timing and the carburetor systems. Even if all the systems are in a satisfactory condition, the engine performance will still depend upon the design of the manifold in the case of multi cylinder engines.
Ineffective design of a manifold may result in a) uneven mixture distribution b) incomplete fuel vapourisation c) reduced amount of charge into individual cylinders and d) different mixture strength of cylinders. The above defects lead to decrease in maximum power output and increase in fuel consumption.
The Intel manifold is a tube casting made of Cast iron or Aluminum. As shown in figure in the case of petrol engine, it consists of an inlet passage to receive fresh charge from the carburetor which is attached by means of studs. According to the number of cylinders there will be an equal number of outlet ports as shown in the figure. This consists of a smooth and short path from the carburetor to the cylinder. It should supply fresh mixture of the same quality and quantity to each cylinder. Sometimes the inlet manifold is kept heated by exhaust manifold heat to help the fuel mixture in the inlet manifold get vapourised.

To improve the charge efficiency the inlet valve of the end pairs of cylinders are placed together as shown in figure. This layout simplifies the design and reduced the number of directional changes in the path of the mixture flow. A side by side arrangement of inlet valves of a pair or adjacent cylinders with a common manifold is called ‘SIAMESED’ arrangement.

Alternate arrangement for a manifold of a six cylinder engine is shown in figure.

Exhaust manifold:
The exhaust manifold connects the engine passages of the engine and leads the engine gases to the silence. It is attached to the side of the engine block or on the engine head according to the exhaust valve arrangement. Gaskets are provided between the seats of the engine block and manifold parts, so as to prevent gas leakages. A tail pipe is also attached to the silence. There should not be any restriction in the passage for flow of gases. Large bends are provided for a stream line flow, thereby reducing the back pressure the arrangement of inlet and exhaust will be in such a way that hot gases are allowed to flow across the inlet manifold. The exhaust manifold should be designed to avoid the possibility of overlapping of gases from two cylinders. The exhaust manifold is made up of cast iron and aluminium alloy.

Exhaust line

The layout of the exhaust line is shown in the figure. This collects the engine gases arm the exhaust manifolds and discharges them at the rear of the vehicle to the atmosphere. It is properly designed and fixed to the bottom of the vehicle by means of bolts and clamps. This arrangement is so designed to have minimum power loss, vibration, noise and back pressure and transfer of heat to the vehicle body.

In modern vehicles, the exhaust system also changes harmful exhaust gases chemically to relatively harmless compounds.

UNIT – II

ENGINE AUXILIARY SYSTEMS

PART - A

1. What are the two main classes of carburetor?

   Constant choke
   Constant vacuum

2. What is a constant choke carburetor?

   It is a type in which the orifice area is constant and the pressure difference (or) depression is varied.
3. **What is a constant vacuum carburetor?**

   A constant vacuum carburetor is a type in which the area of the orifice is varied to meet the changing demands, the depression being kept constant.

4. **What are the different types of carburetors in practice?**

   Horizontal draft, updraft and down draft are the different types of carburetors in practice.

5. **Why do most engines use down draft carburetors?**

   In the down draft type, gravity assists the spraying of fuel and in filling the cylinder engine accessibility improved.

6. **What is carburetor venturi?**

   Carburetor venturi a miniature tapes bore to increase the air velocity and create partial vacuum causing suction of petrol from the float chamber.

7. **What is a carburetor jet?**

   Carburetor jet is a very small hollow plug having a number of holes to spray a metered quantity of fuel.

8. **What is meant by a “submerged jet” and why it is used?**

   A submerged jet is one where the orifice is below the fuel level. It gives a steady uniform discharge as it is not affected by air speed or differences in float chamber fuel level.
9. What is a choke?

The choke is a valve controlling the amount of air passing to the carburetor and is used when starting a cold engine.

10. What is another name of choke?

The choke is also called as the “Strangler”.

11. What is a choke tube?

A choke tube is a small tube around the jet to increase the speed of air for effective atomization of fuel.

12. Why is the float chamber fitted in a carburetor?

To maintain and control the supply of fuel.

13. What is lean mixture and rich mixture?

Lean Mixture: Air is more than the fuel
Rich Mixture: Fuel is more than the air.

14. What is meant by “compensation” and why is it necessary?

Compensation is the proportioning of the amount of petrol to the air, so that the engine always receives a suitable mixture. It is necessary because as the speed of the air past the jet increases, the petrol flows at an even greater rate. (i.e as the square of the air flow).

15. What are the reasons for the engine missing with reference to petrol flow?
Dust particle in petrol
Choked filter
Improperly adjusted ball in the float.
Presence of water in petrol.

16. What is meant by “flooding” of carburetor?

Flooding of carburetor means that the engine cylinders receive raw or liquid gasoline (or) too rich a mixture.

17. What are the purpose of an air bleed?

Too clean a mixture on low vacuum.
Too rich a mixture on high vacuum.

18. What are the causes of higher fuel consumption?

Fuel leakage

Damaged gasket incorporated
Improper use of manual choke
Puncture in float
Improper jet needle.
Under inflation of types.

19. What is “hunting” and how may it be settled?

Uneven running of an engine because of high rich content of a slow running mixture is termed as “hunting” adjustment of the mixture control knob (or) screw to a weaker point will reduce the trouble.
20. How is slow running adjusted in the majority of solex and zenith carburetors?

A stop screw controlling the opening of the throttle.
An adjustable air screw which weakens the mixture when it is unscrewed.

21. What are the limitations and disadvantages of a conventional carburetor?

i. Volumetric efficiency is limited due to restriction of the air flow by the choke.
ii. Mixture distribution is uneven in multi cylinder.
iii. Fuel deposits on the valves of the induction manifold.

22. What are the advantages of petrol injection in a carburetor engine?

Because of the absence of choke and no need of pre-heating specific fuel consumption torque and brake power are high. There is improved torque due to relative ease of port design. It is possible to meter fuel supply accurately for the load condition, through out the speed range.

23. What is the function of the fuel injection pump?

The function of the fuel injection pump is to supply the engine with fuel in quantities exactly metered in proportion to the amount of power required and timed for smooth running with maximum economy.

24. What are the four basic types of fuel injection system?

- Common rail system
- Gas compression pump system.
- Jerk pump system
- Distributor pump system

25. What is an injector?
An unit injector is a small high pressure pump and spray nozzle for an individual cylinder.

26. What are the advantages of the unit injector?

i. It is a single unit with simple design
ii. Can be used for many different engines over a wide range of power outputs.
iii. Removal and replacement does not entail retiming.
iv. Servicing is simple.

27. What faults may be found with fuel injectors?

Incorrect operating pressure
Distorted spray form
Dripping injector
Cracked injector
Broken injector – valve compression springs Injector value striking in its guide.

28. How can we verify whether all the cylinder in an engine are getting fuel and are firing?

Fuel entry firing can be verified by the temperature reading of the exhaust by training the car to detect differences in sounds of the various cylinders and by feeling the water jackets around the cylinders. A cold water jacket indicates that the cylinder is misfiring.

29. What are the main circuits in an auto electrical system?

1. Starting circuit 3. Ignition circuit
2. Generator Circuit 4. Lighting circuit

30. What will happen if a cut – out were not provided in an automobile?
When the speed of the dynamo falls, its voltage will fall below that of the battery and would discharge itself through the dynamo if a cut-out fitted.

31. What is the purpose of the voltage regulator?

The voltage regulator is used to prevent the circuit voltage from exceeding a predetermined value.

32. What is the purpose of a current regulator?

It is used to protect the generator from overload.

33. What do you mean by the lighting and signaling system?

The lighting and signaling system includes head lamps, tail lamps, direction indicators, panel lamps, inspection lamps, roof lamps, the horn, the brake light, the door light, and the number plate light.

34. What is the approximate wattage of the head lamp?

Lies between 37.5 watts and 50 watts.

35. Why is relay included in relay in horn circuit?

Protects the contacts at a horn switch.
Provides direct connection between the horn and the battery.
Allow the use of a short cable of a smaller cross section.

36. What are the main circuits in an auto electrical system?

Starting circuit
Generator circuit
Ignition system
37. What type of dynamo is fitted to a motor vehicle?

   A two pole, two brush shunt type dynamo, which has a rising voltage with increase of speed, is used in a motor vehicle.

38. If the dynamo fails to charge what items should be examined?

   The dynamo field fuse.
   The connections to the dynamo.
   The commutator and brushes.
   The drive to the dynamo if it is by belt.

39. What do you mean by the lighting and signaling system?

   The lighting and signaling system includes head lamps, tail lamps direction indicators, panel lamps, inspection lamps, roof lamps, the horn, the brake light, the door light and the number plate light.

40. Why is relay included in relay in horn circuit?

   Protects the contacts at a horn switch.
   Provides direct connection between the horn switch and the battery.
   Allow the use of a short cable of a smaller cross section.

41. What is the function of starting motor?

   IC engines are not self starting and need to be rotated at a certain minimum speed in order for the engine to commence running by the fuel supply. This is the function of starting motor.

42. State any two troubles of the starting motor.
Starting motor does not turn to crank the engine.
Starting motor cranks the engine slowly.

43. How are the starters liked to the engine fly wheel?

Through a small pinion and which acts as gear reduction.

44. What are the reasons for the failure of a starting motor to crank an engine?

Excessive resistance in cranking circuit.
Excessive engine drive shaft.
Rusted starter drive shaft.
Short circuit in solenoid.

45. Why does a pinion travel forward when the armature of a bendix drive starts to turn?

The pinion is provided with the internal thread which engages with a spiral external thread on a sleeve. So when the armature turns, the pinion is prevented from turning and thus it travels from forward on the sleeve.

46. How is heat for ignition obtained in the diesel engine?

In diesel engine, heat is obtained by compressed air in the cylinders until it has reached a temperature high enough to ignite the injected fuel.

47. What is the probable fault of an engine misfire and how can it to located?

A defective spark plug is the probable fault for an engine misfire. This can be detected by shorting each plug in turn with a screw driver. The one which fails to make any difference in the running of the engine is the faulty one.

48. What is the purpose of an ignition condenser?
49. **What is the essential difference between the magneto and the coil ignition system?**

   The magneto is a self-contained source of electricity whereas the coil system drives in its initial current from the battery.

50. **How is a spark generated in the rotating armature magnet?**

   The armature rotating between the poles of the magnet generate a small current which is led through the primary winding to the contact breaker. This initiated a spark.

51. **Why is it necessary to retard the spark for full throttle operation under load?**

   Under full throttle and load the spark is in advanced stage. So combustion will be completed before the piston has reached TDC. The crank shaft would then have forced the piston upward against high pressure. In such cases force might not be enough to overcome the pressure and the engine would “stall”. So it is necessary to retard the spark.

52. **Why is it desirable to advance the ignition timing when the engine speed increases?**

   When the engine speed increases, ignition must occur a bit earlier in the stroke; otherwise the piston would have crossed the TDC and would have to descend its power stroke before complete burning of the mixture.

53. **What is the voltage required in the spark plug?**

   Between 18000 volts to 25000 volts.

54. **What are the causes of the engine backfire?**

   Late ignition timing, spark plug of wrong heat range and excessive rich mixture are some of the causes of engine backfire.

55. **What are the different foulings that occurs in a spark plug?**
Carbon fouling
High speed (or) Load Fouling
Oil and carbon fouling.

56. What is meant by heat range of spark plug?

The heat range of a spark plug is its stability to transfer heat from the firing end up through the insulator, gasket and shell to the cylinder head of water jacket.

57. What are the reasons for no spark?

Pitted C.B. Point
Short circuiting of coil or condenser circuit.

58. What are the causes for misfire in a scooter?

Excessive gap of spark plug.
Pitted (or) worn out C.B point
Short condenser.

59. What are the reasons for misfire in a scooter?

i. Excessive gap of spark plug
ii. Pitted (or) worn out C.B. point
iii. Short condenser.

60. What is the correct gap between the cut – out points?

The gap between the cut – out points is usually about 0.03 mm and between the armature and magnet face is about 0.06 mm.
61. Why is the spark advance mechanism provided in the distributor?

Spark advance mechanism is provided to make the spark occur little earlier so that the charge burns immediately when the piston reaches TDC.

62. Give a list of main lights in a modern vehicle?

1. Head light
2. Stop light
3. Parking light
4. Backup light
5. Direction signal light
6. Tail light
7. Blinkers light
8. Interior light

63. What is the purpose of direction signal lights?

Which are used to indicate the direction in which the vehicle is to turn.

64. What is the use of tail lights?

Tail lights are illustrate back of the car in the might so that the other vehicles coming behind it are able to see it.

65. What is the use of stop light?

Stop lights are at the rear of the car and becomes on when brakes are applied.

66. What is head light aiming?

The head lights must be aimed correctly to the required direction to get proper lights on the road and to prevent the vehicle from accident.
PART - B

1) Give classification of carburetors?

The carburetors are classified on the following basis:

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1. According to the arrangement of float chamber:
   a) Eccentric   b) Concentric

   1) According to the direction of air-flow
      a) Down draft   b) Side draft
      c) Up draft     d) Semi-down draft

   2) According to the number of units:
      a) Single       b) Dual
      c) Four-barrel

   3) According to the type of metering system
      a) Air-bleed jet   b) Metering rod type

   4) According to the type of venture
      a) Plain venture  b) Double venture
      c) Vane venture   d) Nozzle-bar venture
      e) Triple venture

   5) According to the type of power system
      a) Unbalanced     b) Balanced

   6) According to the type of power system
      a) Manually operated   b) Vacuum controlled

   7) According to the method of varying the mixture strength
      a) Constant choke carburetor
      b) Constant vacuum carburetor

2. Sketch a simple carburetor and explain the construction and working.
In a spark ignition engine, the combustible mixture contains liquid fuel, vapour and air. Air and fuel in proper proportion are thoroughly mixed. The mixture must be sent into the combustion chamber in vapour form. Thus atomization, vapourization and mixing process is termed as carburetion.

**Basic requirements of a simple carburetor**

1. Reliable, durable and simple in maintenance and repairs.
2. Must be able to give full power immediately after starting.
3. Smooth operation at varying loads
4. Good acceleration.
5. Good fuel economy
6. Sufficient power at high speeds.
7. Steady operation at low idling speeds.
8. Even low temperatures, ease of starting.

**Working of a simple carburetor**

The function of the carburetor is to produce a mixture of petrol vapour and air in a correct proportion. The figure shows the main elements of a simple carburetor.
The main components are

1. A barrel which is called Air horn
2. Float Chamber

   a. Flow barrel

   This is almost a tube containing a venture portion. Venturi means a gradual reduction in area in the form of a converging – diverging section. The minimum cross sectional area is called a ‘throat’. At the throat, a narrow pipeline carrying a jet is placed. On either sides of the venturi valves are provided.
   1. Throttling valve to control the flow of mixture.
   2. Choke valve to control the flow of air. If the air flows upwards this is called up-draught carburetor. If it flows downwards it is called down-draught carburetor.

   b. Float chamber

   Float chamber is constant level reservoir for the supply of fuel (petrol). To maintain the constant level a float is provided. The float is made up of a thin sheet metal. The movement of the float is according to the fuel level. The raising or lowering of the float operates a needle valve for closing or admitting the fuel. The pressure inside the float chamber is maintained equal to that of the atmosphere by means of a small vent. The jet in the venturi is connected to the float chamber as shown in the figure.

Choke valve in its simplest form consists of a pivoted plate like a butterfly valve.

   By operating the throttle valve, sufficient quantity of the fuel-air mixture is made to enter into the inlet manifold.
Working

During the suction stroke, vacuum is created in the inlet side. At this allows the atmospheric air to be drawn in. Air enters the throat through an air filter. This causes the fuel to get sprayed out of the jet and get mixed with air.

The throttle valve will be almost closed in the idling operation. At this stage the amount of air flow is not sufficient to induce fuel flow. To compensate this idling jet is provided to increase air/fuel ratio.

3. Explain the Construction and working of solex carburetor with neat diagrams.

Solex carburetor is a down-draught type carburetor. This carburetor is used in Fiat Cars and Willys Jeeps. The float circuit regulates the fuel supply. This Carburettor is similar to the simple type carburetor. The float circuit is provided with a fuel filter, fuel inlet needle valve, float and float chamber.

This carburetor consists of the following circuits.

1. Starting circuit
2. Idle and low speed circuit
3. Normal running circuit
4. Acceleration circuit
5. Float circuit

Starting Circuit

Starting circuit in Solex Carburetor is shown in the figure. There is a startups valve in the form of a disc having a small hole. With the help of a starting lever, this small hole is then brought in front of the fuel supply hole as shown in the figure. A passage is provided to take the fuel supply from the float chamber.
Initially when the throttle is in the closed position the entire inlet suction is applied to the starting passage. At this stage air flows through the air jet, and mixed with the fuel through the small hole in the disc. The mixture is rich enough to start the engine. To increase the speed further the throttle further the throttle valve is opened. The starting lever is brought up to the second position. This reduces the supply of the fuel through the disc valve. In this position the throttle valve is partly opened. At this stage petrol is flowing out from the main jet. Even if the mixture supply is reduced from the starter is reached, the starter is brought to ‘OFF’ position.

Idling and low speed circuit

The slex carburetor is also provided with idling circuit for economy of the fuel. This is shown in figure separately. There is an idle passage for the supply of air through a pilot air jet, and a pilot fuel jet to supply petrol by the engine suction. The air and fuel mixes in the idle passage and comes out through idle port. There is a pipe passage to carry fuel below the throttle valve. Similarly there is a pipe passage to carry air to the throttle valve. The amount of air is adjusted by the pilot air adjusting screw and the fuel by the pilot fuel jet. There is also an idle adjusting screw to adjusting to adjust the mixture strength flowing below the throttle valve.
The idle port is controlled by an idle adjustment screw for smooth running of the engine. After idling period as the engine speed is increased the throttle valve is completely at this stage. Then the idle circuit is slowly put off from action.

Low speed openings are provided on the venturi portion of the throttle valve for smooth transfer from the idling circuit to the main circuit. When the throttle is opened widely, there is decrease in suction at the idle port and this is applied at slow speed opening.

**Normal running**

When the engine is to operate under normal running conditions, the throttle valve is opened partly. Now engine speed is used for further supply of fuel and the main stream of air mixes with fuel. Now the mixture is controlled by the throttle valve.

**Acceleration Circuit**
Solex circuit
When there is a certain load to be met, the diaphragm needs acceleration. So an extra quantity of fuel is to be provided. This is achieved by the diaphragm system as shown in the figure. The diaphragm set against the spring which is operated by a lever is connected to the acceleration pedal. Due to the movement of the pump lever, the diaphragm pushes more due to the main jet. When the force is released this removes the pump lever action. The diaphragm provides pumping action to pump fuel for acceleration.

4. Explain the construction and working of Zenith carburetor.

This type of Carburetor is mostly used in automobiles. This type mainly consists of three jets viz, the main jet the compensating and the idling jet. The arrangement of the Carburetor is shown the figure.

Besides employing two side jets a compound jet consisting of inner main jet and compensating outer annular jet is used. There is a small well opened to the atmosphere. This is easy to start simple to adjust and suitable for economy. The setting or adjustment is also easy and simple.
A pilot jet is provided for starting and slow running operation. The fuel is supplied through filter into the mixing chamber in the closed throttle position. The choke is used for starting and the throttle valve remains almost closed for idling. Engine suction is applied for the supply of fuel to the idle jet. Air is supplied by the pilot jet. In case of idling a separate knob is provided for idling and slow running adjustment. The quantity of the mixture is controlled by varying the air intake by a throttle extension provided with a knob.

As the throttle is opened further some air passes through the venture then the fuel is supplied from the main jet and the slow running jet. The entire suction is applied to the main and compensating jet. As the throttle is further opened, suction at the slow running jet is stopped. Then the fuel adjustment is taken care off by the compensating jet.

5. Explain an electronic fuel injection system with schematic layout.

The fuel injection in diesel engines and fuel supply through carburetor in petrol engines are the standard practice. But there are some difficulties in using carburetor in petrol engines are the standard practice. But there are some difficulties in using carburetor o multi-cylinder engine. The petrol injection system is the correct solution for such limitations. A better development in the petrol injection system is the application of electronic fuel injection. In this the mechanically operated fuel injection pump is replaced by an electronically controlled metering valve.

The schematic layout of the electronic injection system is shown in figure (a). An electrically driven injection pump sucks fuel from the tank and supply to the metering distributor through a pressure control valve.
Figure Schematic layout of an electronic petrol injection system

The injector is held closed with the help of a spring and is opened by means of solenoids. These solenoids are energized by the control signal from the electronic control unit. This unit consists of a small re-programmed analog computer which translates the sensor signals into command signals for fuel delivery. The metering valve injects the required quantity of petrol to the cylinders through the injectors, timed to open at appropriate timings which is controlled by Electronic control unit (ECU).

The strength of the ECU Control signal depends upon the engine requirements which are determined by the ECU from the sensor signals. The sensor signals monitors different engine conditions like inlet air temperature, Engine load, Engine pressure and Engine performance etc.,

An electronic fuel-injection system is a type of a electronic control system. It includes sensors or input devices a controller (ECM or PCM) and various actuators or output devices that are operated by the ECM or PCM.

Figure (b) shows the components in a simplified electronic fuel-injection system. The controller is the engine computer – an Electronic Control Module (ECM) or Powertrain Control Module (PCM). It is also called the onboard computer because it is carried “on board” the vehicle.

Various parts of the engine and fuel system have sensors that send electric signals to the ECM. Each sensor is a device that receives and reacts to a signal such as a change in temperature, pressure or voltage. Some sensors report to a signal such as a change in temperature, pressure or voltage. Some sensors report the amount of air entering. Using this information, the ECM continuously calculates how much fuel is to injected. If then opens the fuel injections, so the proper amount of fuel is sprayed out to produce the desired air-fuel ratio.
6) Explain the mono point fuel injection in an automobile.

In a single point injection system, the petrol injection is through a single injector. This is similar to the single carburetor supplying fuel mixture to different cylinders. The injector nozzle supplies the fuel spray by distributing to the individual cylinder of a multi-cylinder engine. Air is induced separately into the cylinders. Inspite the advantages of petrol injected still problem of uniform distribution of fuel among the cylinders may exist.

**Throttle body system (TBI)**

Throttle body injector is a single or mono point injection system. The throttle body is similar to the carburetor throttle body, with the throttle valve controlling the amount of air entering the intake manifold as shown as figure.
An injector is placed slightly above the throat of the throttle body. The petrol is spread in to the air in the intake manifold and gets mixed with air. Then this mixture passes through the throttle valve and enters into the intake manifold.

7. Explain multipoint fuel injection system with neat diagrams.

In multi point system a separate injector for each cylinder is mounted in the inlet manifold. The fuel is injected into each intake port on the manifold side of the inlet valve, so that the mixture preparation and distribution is high. By using throttle body and butterfly valve at the intake system the air flow is metered and controlled. Refer figure.

To pump to the fuel tank and electrically driven fuel pressure pump is mounted near the fuel tank. The fuel pressure pump pumps the fuel at a specified pressure (about 700 kpa) into a metering distributor. The fuel supplied to the distributor unit should at constant
pressure so that a relief valve fitted near the distributor return the excess fuel to the tank. The high pressure fuel is injected for each injection in turn by metering system by engine manifold pressure. The quantity of fuel delivered is also controlled in the distributor system by engine manifold pressure. The quantity of fuel delivered by metering distributor is controlled by a manual control on the dash board.
Port injection

Port injection arrangement is provided with an injector placed on the side of the inlet manifold as shown in the figure. This refers to multipoint fuel injection. The injector sprays the petrol into the air stream in the inlet manifold. Then the petrol-air mixture passes through the inlet manifold. Each cylinder is provided with an injector in its inlet manifold.

8. Explain the construction and operation of a lead acid battery with a neat sketch.

The battery is the heart of the electrical systems in an automobile. It supplies the essential current. It is an electrical device used for storing energy in chemical from which can be released as electricity as and when required. The battery supplies the current for starting the motor and the ignition system when the engine is being cranked for starting. Battery serves to supply the current for light, radio, heater and other accessories. Thus the battery is the secondary source of electrical energy in addition to the generator.
The main functions of a battery
1) To provide a source of current for starting and ignition.
2) To supply current when the demand exceeds the generated output.
3) To control the voltage of the electrical system.

Types of batteries
1) Wet. 2) Dry

A wet battery before put into service is to be charged by an external source after being filled with the electrolyte. In the case of dry battery it consists of fully charged positive or negative plates. Dry battery can be put to service immediately after filling electrolytes.

Other types are
1) Lead Acid batteries
2) Alkaline batteries
   a) Nickel-iron battery
   b) Nickel-cadmium type
3) Zinc-air battery.

The lead acid battery is mostly used in automobiles. The principle employed in this case is as follows:

There are two rods; one is of pure lead and other rod is of pure lead peroxide which are in a solution of dilute sulphuric acid as shown in the figure. Then an electric voltage is generated between the rods, the lead peroxide forms the positive pole and pure lead forms the negative pole.

Depending upon the type of cells, the battery is classified into two types – 1) Alkaline battery 2) Acid battery

The acid battery is widely used in automobiles because of its low internal resistance and low cost. This battery is also called as storage battery or accumulator or secondary battery. The cell in the secondary battery can be recharged by passing an electrical current through it. If it is primary it can not be recharged. Example: Dry cell battery.
The battery consists of cells. The cells are made of two plates; one of positive (+) plate and another of negative (-) plate. The plates are separated by a separator. The simplest storage battery is shown in the figure.
The plates carry an active material which is cast by a lead grid. The active material of the positive plate is lead peroxide (PbO₂) and of the negative plate is spongy lead (Pb). These plates are immersed in a chemical solution. The chemical solution contains 25% of sulphuric acid in water. The separators are made of wood or porous rubber. A number of positive plates and negative plates are arranged alternatively with a separator in between them to form a cell. All positive plates are connected to a lug cast with a grid. This forms the positive terminal; similarly the negative plates are connected to another lug.

**Construction**

This is a lead acid type provided with six cells generating totally 12V, each cell consists of two plates – one positive and negative. The main components of the battery are 1. Container 2. Plates 3. Separators 4. Cell covers and 5. Electrolyte.
The other accessories include cell-element, cell connector, tapered terminals and sealing compound. A simple construction of a container is shown in the figure.

**Container**

This is a single moulded piece as shown in the figure. This is made of hard rubber or plastic. It is divided into compartments over different cells by providing partitions. At the bottom there are four bridges for placing the battery plates. This avoids the short circuiting of the plates.

An opening is provided in each compartment for pouring distilled water and to check the specific gravity. These openings are sealed by screw plugs which are vented to allow the gases formed during charging to escape.

**Plates**
The battery cells consist of positive and negative plates which are called elements. The positive plate is with the grid filled with a spongy lead. Both the plates are immersed in an electrolyte of dilute sulphuric acid. The storage capacity of the battery depends mainly on the effective area of the adjustment plates. The plates are sandwiched-alternately with positive and negative plates. The number of positive plates is less by one than the negative plates so as to make use of all the surfaces of positive plate. The cell terminals are connected to a plug in each plate, arranged in a series. The plates are separated from each other by placing glass mat, micro-porous, rubber, wood or PVC separators. The grids of both the plates are connected to lead-antimony straps.

Separators

These are place between the negative and positive plates to avoid short circuiting. These are thin sheets of non-conducting porous materials. These are made from chemically treated micro-porous, rubber, plastic or fibre glass sheet.

Battery rating

Battery voltage depends upon the number of cells being connected in any series. But the current depends on the total volume and area of the active plate material the strength and the amount of electrolyte. The different methods of battery rating are as follows:

Hour rating

The fully charged battery is maintained at room temperature and the discharge is adjusted at the rate of 5% of the ampere 9 hours capacity. During this testing the cell voltage should be above 7.52 volts.

Minute rating

With the generator not operating and the battery maintained at room temperature, the battery should discharge for a minimum of 20 minutes with the voltage not dropping below 1.5 volts. This condition is known as 20 minute rating.

Cold Rating

This shows the starting ability of the battery when used in cold weather. This rate refers to the time in minutes to start a battery delivering 300 amperes at 18° C without the cell voltage dropping below 1 Volt.
Operation

When mixed with water, Sulphuric acid acts as a good conductor of electricity. Ions are produced in this electrolysis process. These ions act and carry electric charges which get deposited on the electrodes. Moreover, these ions also react chemically with the electrodes. When the positive and negative terminals absorb respective electric charges, a back E.M.F is developed in the opposite direction of the applied voltage. Now, a reversible chemical is supplied to the external circuit during the discharge process. In this chemical reaction, water is liberated and the specific gravity of the electrolyte is reduced.

The battery can be charged later by the generator in the car itself or by a separate battery charger. In this case, the above said chemical reaction is reversed thereby raising the specific gravity of the electrolyte. The chemical reaction for charging and discharging is given below.

\[
PbO_2 + 2H_2SO_4 + Pb \rightarrow PbSO_4 + 2H_2O + PbSO_4
\]

In the chemical reaction between lead peroxide (positive plate) and lead (negative plate) through sulphuric acid in electrolyte, current is generated and flows to the external circuit. The battery with a full charge will have a specific gravity of 1.26 to 1.28 with 25% sulphuric acid.

9. Explain the construction and operation of the Generator.

Generator is a device to convert mechanical energy from the auto engine into electrical energy. These supplies current to operate electrical devices like ignition switch, light switch (in place of battery) and keeps the battery fully charged.

The automobile engine generator is usually a low voltage DC generator, producing direct current, this generator, otherwise known as dynamo, is mounted on the one side of the engine block. It is driven by a fan belt. In automobile engines mostly commutator type shunt-wound and self-generating energizing generator unit is employed.

Generator construction

A commutator type generator is shown in the figure.
Frame or Body: It is cylindrical shell made of steel. The inner surface of the body is well machined so as to accommodate the pole shoes. Both the ends of the body are covered by means of end frames in which bearings are provided to support the armature shaft.

Armature: It consists of laminated iron sheets cut in desired size and shape which are pressed together and mounted on a teak shaft in the form of a core. The core has longitudinal slots in which are installed from each other and from the shaft. This complete unit of the segments which rotates with the shaft is called commutator.

Field Coils: These are copper wires used to electromagnetise the poles by passing current through them. About one fifty of the total output is consumed as field current. The supply to all the circuit is taken from two carbon brushes, held in the holders by means of springs and which also have the firm contact with the commutator segments.

Generator control mechanism
Suppose the engine is running at a low speed and the current produced is of high amperage the current that would be available at still higher speed would be excessive and may damage to electrical system. Therefore some means are essential to adjust and control the generator voltage and/or current.

**Functions of the control mechanism**

a) To control the wide spread range of generator voltage  
b) To adjust the generator output itself, according to the need of the system.  
c) To adjust the battery charging rate according to the condition of the battery.  
d) To disconnect and reconnect the battery from the generator with respect to the engine speed.

**10. Explain the cutout relay in automobile battery.**

Cut out relay is a circuit breaker or an automatic switch which opens and closes between the generator and the battery. Some means are necessary to prevent the battery from discharging through generator. When the engine runs at low speed, the generator is not enough to charge the battery. It is necessary to connect the battery to the generator when the generator is producing current. Therefore some system is needed to switch on the generator into the battery circuit as soon as the generator out-put reaches a predetermined value, and to switch off the circuit when the value falls very below. The process of connecting and cutting out of the battery from the generator circuit is done by “Cut out relay”.

Cut out relay consists of a soft iron core on which two coils are wound one with a fine wire called voltage coil or the shunt coil, which is connected across the generator terminals. The other one is of thick wire called “current coil”, and is in series with the battery. An armature is hinged as shown in the figure. The contact points are usually held open by the tension of a spring. When the generator is not running at high speeds to develop sufficient voltage, as the speed raises, the current flowing coil increases. This produces sufficient magnetism to pull the armature to cut out the core. The contact points are closed and circuit is completed between the battery and the generator and the soft iron core is in the same direction as the magnetic effect produced by the voltage coil. This makes the contacts firm and tight. When the generator falls to a low value, so that induced e.m.f. is well below the battery voltage then the current flows in the opposite direction. The discharge current flows from the battery to the generator through the current coil in a direction opposite to that of the charging current in the voltage coil. Thus core is demagnetized thereby opening the contact points and disconnecting battery from the generator.
Regulators

The regulator is a device to control the output of the generator and connected between armature and the field terminals of the generator. With the high speed of the generator the high voltage and current output is prevented from damaging the system. This regulator also ensures the rated output at normal speed. The generator output gets controlled by controlling either the speed or strength of the field by controlling the current flowing in the field windings. This is achieved by removing or adding a resistance in the field circuit. This is the principle of the regulator. There are three types of regulators viz. 1) Voltage regulator 2) Current Regulator and 3) Current – voltage regulator.

11. Explain the construction of starter motor and its functions with neat diagrams.
The starting motor for an automobile is mainly of two different types 1. Bendix drive 2. Solenoid drive

Construction of starter motor

A starter motor consists of an outer shell, armature commutator, winder and the starting device.
The starting motor is just for starting the engine when some cranking to engine is needed. Cranking is either by manual operation with the help of a handle or by incorporating any other unit with the engine. Thus any system which converts electrical energy of the battery into mechanical energy, that can be used for cranking the engine is called “Starting Motor”. Circuits are shown in the figures. This is normally fitted on the side of the engine.

**Drive for the starting motor**

The Starter Motor is coupled to the engine fly wheel. The gear mechanism helps for any speed reduction. A ring gear is attached to the fly wheel. A pinion gear is fixed to the starter shaft which drives the ring gear. The starter shaft is the driver and ring gear is the driven unit. When the two gears are engaged the engine is cranked. The arrangement will be in such a way that once the engine gets started, the gear pinion disengages automatically. The gear ratio is roughly 15:1. Starting motors are classified according to the drive arrangement and automatic engagement and disengagement of the motor. Generally there are three types of starting devices in use:

a) Bendix drive  
b) Over-running dutch drive  
c) Solenoid starter switch
This is a good example of inertia drive. The motor used is a series motor. In a series motor the field winding is in series with the armature winding. Because of this arrangement the same current flows through both the windings.

To crank the engine which is at rest maximum torque is required. Once the cranking continues less torque is sufficient. A series motor fulfills this requirement.

Within a cylindrical housing, steel pole shoes are secured. The number of poles varies from two to six. Two poled windings and four poled windings are common. The field coils are held by the pole shoes. Thick flat copper wires are used as field coil windings. As the adjacent poles are of opposite polarity, windings are on the opposite polarity, windings are on the opposite direction. The armature rotates between these pole shoes when the electric current flows through its winding. The armature is nothing but a slotted iron core fixed on to a shaft. Thick insulated copper conductors are positioned over the armature slots. Thus the conductors are connected in the form of coils. The end of the conductors is connected to the commutator. As shown in the figure the commutator in the slotted core is secured in all the slots. The conductors form the winding of the armature.

**Working**

When the current passes through the terminals it passes through the field winding armature winding and through a carbon brush and comes out through another carbon brush and finally back to the battery. As the current passes field windings are energized. This creates a magnetic field between the pole shoes. The current flowing in the armature winding causes the conductors in the field to face a mechanical force. The resultant of the force makes the armature rotate.

**12. Draw the wiring circuit of a modern car lightly system.**

Lighting system is responsible for the operation of the various lights in an automobile. Among them the important lights are: 1. Head lights 2. Parking lights 3. Tail lights 4. Direction signal 5. Interior lights etc.

The lighting system consists of the following main components which are connected through electrical wiring to complete the circuit.

1. Various lamps
2. Switches
3. Fuses and circuit breakers
4. Junction boxes

The system consists of the following main circuits:

1. Horn circuit
2. Trafficator circuit
3. Vibration circuit
4. Speedometer circuit.

A simple circuit of the lighting is shown in the figure.
The circuit shows all details such as switches and lamp which receive the power from the battery thought proper wiring. The circuit is a single circuit with one ground wire. Normally a 12 volt battery is used as a source. Suitable switches and fuses or circuit breakers are provided in the system to protect it forms overloading. The circuit begins at the battery passes through the ammeter and a fuse before it approaches any switch.

The stop light is controlled by the respective switch in the brake system. Dim light is controlled by hand operated pilot switch or by an automatic door switch which completes the circuit and the light switch on the instrument panel controls all other lights.

In the light switch there are two or three positions viz., (a) Parking light circuit which includes complete the parking light, tail lights and other instrument lights. b) Head lamp position – this circuit sends current to the head lamps as well as to the tail lights, license plate light, instrument lights etc., A dimmer switch can be made use of to indicate the flow of current.

Additional switches may also be connected to the same side of the ammeter as shown in the figure through some fuses. Fuses used in automobiles are of low melting point. Due to overload or short circuiting the fuses burn out and break the circuit. Sometimes the circuit breakers are employed to prevent the excessive amount of current. These are nothing but current limiting relays. Vibrating type circuit breaks are mostly used. A number of junction boxes may be conveniently used for electrical lines.

Normally the main light consists of Head lights, parking light, Tail or stoplight, Dash board light, cap and Body lights. Apart from the above, the lighting system consists of the following components also:

a) Switches; main light, switch, dipper switch and stop light.
b) Fuses.
   Fuses are of the cartridge type made of fine lead alloy
c) Circuit Breakers:
These are employed instead of fuses in the circuit to prevent the flow of excessive current. These are simply current limiting relays. Some of the types in use are: the Vibrating type, the Lockout type and Thermal type.

13. **Explain the construction and working principle of Battery ignition system.**

The main components of the conventional ignition system are: A battery, ignition coil, breaker points, condenser, distributor and spark plugs.

The ignition distributor consists of contact points, condenser, arrangements for centrifugal advance and the rotor. This unit is driven by the cam shaft at half the engine speed in the case of four stroke engines.

The ignition coil with a water proof casing is provided with a primary winding of approximately 200 turns of copper wire wound on a soft iron core. 18000 turns of copper wire, wound upon the primary, serves as the secondary winding.
A schematic diagram showing the arrangement of the spark ignition system is shown in the figure. As the breaker points are closed, current flows through the primary winding. This builds up a magnetic field around the coil. In expansion the primary winding is cut by the magnetic field built up. Because of this a back e.m.f. is induced which opposes the battery current. A voltage is also induced in the secondary winding. But at this stage it is too low to induce a spark.

As the rotor rotates, the cam on the distributor shaft opens the contact points. This opening collapses the magnetic field built around the coil. The collapse of the magnetic field also cuts the secondary winding, including a high secondary voltage. This process causes a very high voltage to pass through the secondary winding. This is then, passed to one of the spark plugs. When sufficient voltage is available in the secondary to overcome the resistance of the spark plug a spark is produced and crosses the gap. The mixture surrounding and within the gap of the spark plug gets ignited.

14. **Explain the construction and working principle of magneto ignition system.**

In this system there is no need for the storage battery to provide the spark. The Magneto ignition system itself generates current, boosts the low voltage and distributes it to the individual cylinder. The basic principle of magneto is that electricity is produced by a revolving coil of a wire in a magnetic field.

A magneto consists of a primary and secondary circuit. Both circuits have windings which surround the same iron core. The magneto on the fly wheel or rotor acts on both circuits. As the fly wheel rotates, polarity of the magnetism in and around each coil is changed. Thus current is induced contact breaker points and a condenser are provided in the primary circuit to control the magnetic effect.

**Classification**

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The magnetos are classified as:

1) With regard to the current produced – the high tension and low tension
2) With regard to their revolving part – rotation armature type; rotating magnetic type and polar induction type. Refer figures.
15. Explain the working principle of Electronic ignition system with neat sketch.

A simple circuit of electronic ignition system is shown in the figure. Similar to the battery ignition system, spark plugs, distributor, ignition coil, battery are provided. But a timer is included in the distributor instead of the contact breaker. This is called as Electronic-Ignition Control Unit (ECU).

Various types of switches can be used as the primary trigger. This is the device in the ignition system that causes the primary current to the switched on and off. Electronically the switching action may be triggered by a magnetic pickup coil, Hall – effect switch, or
light beam. The action of the primary trigger signals the ignition may not have a separate ignition module. The engines or powertrain control module (ECM or PCM) controls the ignition system.

Secondary circuits are basically the same in most ignition systems. However, many electronic ignition systems produce higher secondary voltage than contact–point systems. The voltage in these high–energy ignition (HEI) systems may reach 47,000 volts or higher. This allows the use of spark plugs with wider gaps. The longer spark can ignite leaner air-fuel ratios. These provide better fuel economy and reduced exhaust emissions. The distributor (if used), coil, and secondary wiring are also redesigned to handle the higher voltage. Distributor caps are larger with spark-plug terminals farther apart. This reduces the possibility of arcing between the terminals. A arcing can cause engine miss and damage to the cap. Most electronic ignition systems use the larger 8-mm silicon spark-plug and coil cable.

UNIT – III
Transmission systems
PART - A

1. Why is a gear box necessary in an automobile?

Gear box is necessary to regulate both the power output and the speed range of the engine relative to the vehicle speeds.

2. What are the different types of gear boxes used in an automobile?

1. Sliding mesh gear box
2. Constant mesh gear box
3. What is a preselector gear box?

A gear box fitted with a special mechanism which enables the driver to select the gear before hand is known as a preselector.

4. Why are breather plugs fitted in some of gear boxes?

Breather plugs allow air to get in or out depending on oil in the gear box being cold or hot respectively.

5. What is tractive effort?

Tractive effort is the driving force that acts at the driving wheel to propel the vehicle. Tractive effort is proportional to engine torque.

6. Why are the helical gears preferred in transmission?

It is easier to distribute the load among two or more teeth simultaneously. These can be made lighter and to functional highest speeds without any vibration. Their operation is silent and smooth.

7. What is known as selective transmission?

Selective transmission refers to the type of transmission in which it is possible to select any gear sped directly from the neutral position.

8. Why is sliding mesh type gear box not preferred?

More force required to engage the gears
More noise is made while changing.

9. Why is double - de - clutching necessary?
   Double de – clenching is adopted to have quick and quieter change of gears.

10. What is the function of the free wheel in over drive?
    With the free wheeling device, power transmission from the main shaft to the output shaft is possible when the sun gear is locked.

11. What is meant by one way clutch?
    IT is an apply device the operation of which is similar to the operation of an over running clutch used in a starter. It transfers the motion in one direction and not in the other. When rotated in the opposite direction the rollers retract out of the way and allow the clutch to slip.

12. Where normally is the free wheel placed? Why?
    The free wheel is placed usually on the rear end of the gear box. This makes the engine idle at the controlled sped under over run conditions, without the need for selecting neutral gear.

Over Drive and Fluid Flywheel:

13. Why is the fluid wheel provided in automatic transmission?
    The fluid flywheel is provided to cushion the impact of the automatic shifts as well as to reduce the torque reactions of the engine.

14. How does a pump in torque converter differ from the impeller of a fluid coupling?
Though the pump resembles the impeller of a fluid coupling, the blades of the pump are curved in such a design so that most of the oil is thrown out to form a hollow cylinder shape parallel to its axis rotation (vertex flow) when the pump is rotating.

15. What is the function of the free wheel in overdrive?

With the free wheeling device, power transmission from the main shaft to the output shaft is possible when the sun gear is locked.

16. What are the advantages of overdrive?

Overdrive reduces engine wear and vibration. It also reduces the fuel consumption.

17. What is meant by one way clutch?

It is an apply device, the operation of which is similar to the operation of an over running clutch used in a starter. It transfers the motion in one direction and not in the other. When rotated in the opposite direction the rollers retract out of the way and allow the clutch to slip.

18. What is the special feature of the free wheel?

The free wheel transmits torque in one direction only and is generally used to disengage the drive automatically when torque is applied in the reverse direction.

19. Where normally is the free wheel placed? Why?

The free wheel is placed usually on the rear end of the gear box. This makes the engine idle at controlled speed under over run conditions without the need for selecting neutral gear.

20. What is an overdrive?

Overdrive is a device interposed between the transmission and propeller shaft to permit the propeller shaft to run faster than or overdrive the transmission main shaft.
21. What is the fluid drive?

The fluid drive is one name for liquid coupling to transmit turning effort from the engine to the clutch. It is located between the crank shaft and the clutch.

22. What is the main advantage of liquid coupling?

A liquid coupling, when used with a conventional clutch and transmissions enables the driver to use the clutch and gears with less skill and fatigue than with an all mechanical linkage.

23. Why is automatic transmission preferred for commercial vehicles?

Because of reduced drive line maintenance and increased passenger comfort and safety. The driver has other controls also to operate while driving the vehicle. The vehicle is in move even in heavy crowds.

24. What are the three major rotating elements in a torque converter?

A engine driven pump
A fluid driven turbine
A starter.

25. What is an universal joint?

Joint which permit power to be transmitted from one shaft to another which are not in alignment is known as universal joint.

26. What are the various universal joints in use?

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Cross type universal joint
Ball and trunion universal joint
Constant velocity type universal joint.

27. What is the major draw back of Hook's type universal joint?

Suppose one of the shafts in Hook’s joint is revolving at a constant speed, then the other shaft will not revolve at the same constant speed; but during two parts of the revolution, the shaft revolve at slightly lesser speed and for the other two parts at a slightly greater speed than the constant speed of the first shaft.

28. What is a constant velocity type universal joint and what is the advantage?

A joint which does not allow variation in angular velocity occurring in each revolution is known as constant velocity universal joint.

The advantage of the constant velocity universal joint is the elimination of transmitted speed fluctuations.

29. How does the ball and trunion universal joint differ from the cross type?

Ball and trunion joint permits shaft end play, so that there is no need for the slip joint unlike in the cross type.

30. What is known as ball and socket joint?

A ball and socket joint is a flexible joint consisting of a ball with in a socket, used in suspension systems and valve train rocker arms.

31. What is meant by companion flange?

To form universal joint some times forged steel “Yokes” for the joints are welded on the each end of the propeller shaft. This making part of the transmission or drive axle to the drive shaft is called as companion flange.
32. Name the various methods of transmitting power from the engine to the wheels?

1. Direct coupling
2. Chain drive
3. Propeller shaft drive
4. Belt Drive

33. How does the torque tube drive act as a shock absorber?

When a vehicle travels over a bump or when the brakes are applied. The axle moves up and down. In this situation the torque takes up the jerk and keeps the axle straight saving the propeller shaft from jerk. In this way the torque tube acts also as a shock absorber.

34. What is a slip joint?

A joint comprising an external splined end and an internal splines of the joint integral with the universal joint hub is called as slip joint.

35. What is the purpose of a slip joint in the drive line and why it is used in the propeller shaft?

A slip joint lengthens (or) shortens the drive shaft. It is used to compensate for the axial movement of the propeller shaft during up and down motion of the rear axle a slip joint is used.

36. What is meant by “double caridon” joint?

This is a type of constant velocity joint with two crossed and yoke V – joints mounted back to back with a linking yoke and a centering ball.

37. What are the different types of final drive?

- Worm and wheel type
- Spiral bevel gear type
Differential and Rear Axle:

38. What is meant by differential?

Differential is the mechanism housed in the drive axle, which drives the outer wheel faster than the inner one while taking a turn.

39. What is the function of a differential mechanism?

The function of a differential mechanism is to keep both the rear wheels at the same speed in straight travel; to make the outer rear wheel to rotate faster than the inner one during a turn.

40. What is meant by limited slip differential?

It is a differential designed so that when one wheel is slipping, a major portion of the drive torque is supplied to the wheel with the better traction. This is also called a non-slip differential.

41. What is meant by "straddle mounting"?

To avoid radial movement of the pinion in differential the pinion is offered straddle mounting. That is the drive pinion for heavy duty application is supported, properly.

42. What is live axle and dead axle?

Live axle is one which turn within a tubular housing.

A dead axle is a solid axle mounted to the springs with a spindle at each end upon which eh wheels turn.

43. State the functions of the front axle.
Bears the front weight of the vehicle.
Turns the front wheel easily.
Provides cushioning effect through a spring.

44. What is known as the “fully floating” axle?

In a full floating axle, the entire load of the vehicle is taken by the axle housing, while the axle shaft is responsible to act as a driving shaft.

45. What is a three quarter floating type rear axle?

In a three quarter floating type rear axle, the bub is fitted over the axle tube with the axle shaft locked with the drum. In this arrangement, load is shared by the axle shaft and the axle tube.

46. Why is reversed elliot type front axle used in most of that vehicle?

Because,
- It aids equal distribution of load on the stub axle.
- Steering is easier.
- Simple manufacture design is available.

47. Why is the section of the front axle elliptical at the end and I – section at the middle?

The axle has to take bending loads due to the weight of the vehicle. SO I – sections are prepared at the middle and for torque loads due to the braking of the wheels, elliptical sections are prepared at the end.

48. What is meant by two by for drive?

In this arrangement, power is not transmitted directly from the engine to the front axle, but through wheels like dead axle drive in heavy vehicles.
49. What is meant by four by four drive?

In this arrangement, the front axle receives power directly from the engine like live axle in jeeps.

50. Which type of rear axle is in use for?

(a) Heavy vehicle  (b) Light Vehicle

Heavy Vehicles → Full floating axle
Light Vehicle → Semi – floating axle.

51. Name the types of rear axles used in various Indian vehicles?

- Semi floating – Fiat and jeep
- Three quarter floating axle – Ambassador
- Full floating axle – Trucks, Buses and other heavy vehicles.

52. Why does the rear axle in the trans axle need universal joints? Where are they placed?

In some cars the trans axle is mounted in the rear axle so that the live axles are independently sprung. SO universal joint are necessary to drive the live axles. They are placed between the differential side gear and extension of the axle.

PART – B

1) What are the requirements of a clutch?
a) **Torque transmission:**

The clutch should be able to transmit maximum torque of the engine.

b) **Gradual engagement:**

The clutch should engage gradually to avoid sudden jerks.

c) **Heat dissipation:**

The clutch should be able to dissipate large amount of heat which is generated during the clutch operation due to friction.

d) **Dynamic balancing:**

The clutch should be dynamically balanced. This is particularly required in the case of high speed engine clutches.

e) **Vibration damping:**

The clutch should have suitable mechanism to damp vibrations and to eliminate noise produced during the power transmission.

f) **Size:**

The clutch should have suitable mechanism to damp vibrations and to eliminate noise produced during the power transmission.

g) **Free pedal play:**

The clutch should have free pedal play in order to reduce effective clamping load on the carbon thrust bearing and wear on it.

h) **Easy in operation:**

The clutch should be easy to operate requiring as little exertion as possible on the part of the driver.

i) **Light ness:**
The driven member of the clutch should be made as light as possible so that it will not continue to rotate for any length of time after the clutch has been disengaged.

2) List the various types of clutches?

a) Friction clutch
   a. Single plate clutch
   b. Multi plate clutch
      i. Wet
      ii. Dry
   c. Cone clutch
      i. External
      ii. Internal
   d. Centrifugal clutch
   e. Semi-centrifugal clutch
   f. Conical spring clutch (or) Diaphragm clutch
      i. Tapered finger type
      ii. Crows spring type
   g. Positive clutch – dog and spline clutch
   h. Hydraulic clutch
      i. Electro-magnetic clutch
   j. Vacuum clutch
   k. Over running clutch (or) free wheel unit.

3) Describe the construction and working of the single plate clutch?
It is the most common type of clutch used in motor vehicles. Basically, it consists of only one clutch plate, mounted on the splines of the clutch shaft, as shown in figure. The flywheel is mended on the engine crankshaft and rotates with it. The pressure plate is bolted to the flywheel through clutch springs and is free to slide on the clutch shaft when the clutch pedal is operated. When the clutch is engaged, the clutch plate is gripped between the flywheel and the pressure plate. The friction linings are on both the sides of the clutch plate. Due to the friction between the flywheel, clutch plate and pressure plate, the clutch plate revolves with the flywheel. As the clutch plate revolves, the clutch shaft also revolves. Clutch shaft is connected to the transmission. Thus, the engine power is transmitted to the crankshaft to the clutch shaft.

When the clutch pedal is pressed, the pressure plate moves back against the force of the springs, and the clutch plate becomes free between the flywheel and the pressure plate. Thus, the flywheel remains rotating as long as the engine is running and
the clutch shaft speed reduces slowly and finally it stops rotating. As soon as the clutch pedal is pressed, the clutch is said to be disengaged, otherwise it remains engaged due to the spring forces.

4) Describe the construction and working of the multiple clutches?

Multiple clutch consist of a number of clutch plates, instead of only one clutch plate as in the case of single plat clutch. As the number of clutch plates are increased, the friction surface also increase. The increased number of friction surfaces obviously increases the capacity of the clutch to transmit torque. The plates are alternately fitted to the engine shaft and gear box shaft. They are firmly pressed by strong coil springs and assembled in a drum. Each of the alternate plate slides is grooves on the flywheel and the other slides on splines on the pressure plate. Thus, each alternative plate has inner and outer splines.

The multiple clutches works in the same way as the single plate clutch, by operating the cultch pedal. The multiple clutches are used in heavy commercial vehicle, racing cars and motor cycles for transmitting high torque.

The multiple clutches may be dry or wet. When the clutch is operated in an oil bath, it is called a wet clutch. When the clutch is operated dry, it is called dry clutch. The wet clutches are generally used in conjunction with, or as a part of the automatic transmission.
5. Explain the construction and working principle of diaphragm clutch with neat diagrams.

Figure shows the construction of the diaphragm clutch. The construction is almost similar to the single plate clutch, but for the diaphragm springs. As a separate piece, the diaphragm spring is conical. When pressure is applied, it gets flattened.

The diaphragm spring produces sufficient pressure on the pressure plate to engage the clutch. The diaphragm is held between two pivot rings. The rear pivot ring is in the clutch cover. In the engaged position, the spring is made to pivot or rest on the rear pivot ring as shown. At this stage, the outer ring comes in contact with the pressure plate. The spring in the conical shape as shown in Figure 3.5 exerts sufficient pressure and makes the pressure plate be in firm contact with the clutch plates and the fly wheel.

To disengage the clutch, the pedal is pressed. This causes the linkage to move the throw-out bearing towards the fly wheel. Throw-out bearing presses the centre portion of the conical spring to move, thereby removing the pressure on the pressure plate. The clutch disc is released from contact with the driving members. Thus, the pressure plate is removed and the clutch is said to be engaged.
Advantages:

1. Lesser operating effort is required.
2. Constant and uniform loading on the driven plate is made available.
3. Accurate balancing is made available always and heavy vibration is avoided.
4. Design is compact, no need of release levers.
5. Comparatively less affected by the centrifugal force; it can withstand higher rotational speeds.
6. Explain the centrifugal and semi centrifugal clutches with neat sketches.

CENTRIFUGAL CLUTCH

In this arrangement, the centrifugal action of fly-weights is made use of for engaging and disengaging the pressure plate. A simple arrangement is shown in Figure 3.6; in which the clutch pedal and the springs are eliminated. The functioning of the clutch is automatic and depends upon the engine speed. In this arrangement, there is no need for specific operation to disengage the clutch. The vehicle can also be stopped with the gear load, without stalling the engine. The vehicle is controlled by the accelerator pressure and gear transmission at the starting only. This arrangement makes the driving operation very easy and convenient.
As the speed increases, the fly-weights move outwards due to centrifugal force. This movement operates a bell rank lever and presses the floating plate. As shown in the figure, there are helical springs between the floating plate and pressure plate. The force is transmitted to the pressure plate through the springs. The pressure plate containing the friction lining pressure the clutch. There is one more set of springs on the back side of the pressure plate as shown in the figure to keep the clutch in disengaged position at low speed. A projection or a strip called stop is also provided to limit the movement of the fly-weights and the amount of the centrifugal force. Even if the speed is increased beyond this limit, the pressure on the plates will remain constant.

**SEMI-CENTRIFUGAL CLUTCH**

In this arrangement, the motion is transmitted partly by the springs and partly by the centrifugal force. The spring action is effective at normal speeds like the conventional clutch.

For higher speeds the centrifugal action of fly weights is made use of. The constructional details are simplified in the figure. In this arrangement, three hinged levers and three clutch springs are arranged alternatively at equal intervals.
The lever is provided with a fulcrum at the bottom, hinged to the pressure plate at the top as shown in Figure 3.7. They fly weights are placed at the upper end of the lever with an adjusting screw provided at the bottom end of the lever. Centrifugal force on the pressure plate can be slightly varied by adjusting this screw.

As stated earlier, the pressure of the springs is enough for torque transmission at normal speeds. When the speed increases, the fly weights move out due to the centrifugal force and operate the fulcrum to press the pressure plates.

7. Explain the over running clutch with the sketch. Give some advantages of free wheel?

Free Wheel Unit

This is called free wheel clutch and is plated next to the gear box. The construction is shown in Figure 3.8. The driving member is connected to the gear box shaft while the driven member is connected to the propeller shaft, as shown in the figure. There are three slots
or recesses provided with spring actuate rollers through wedges provided in between the two members. In these wedge portions springs and rollers are placed as shown in the figure 3.8. When the driving members is rotating in the direction as shown in figure, the balls or rollers are jammed and the driven member is also rotating in the same direction. But, if the vehicle comes down a hill, then the condition is reversed as the outer one becomes the driving member, and the inner member the driven one. Thus, connection is automatically disconnected from this unit. So, when the direction of the inner member is opposite, the gear box and engine are isolated from the wheels. In the reverse drive, free wheel is to be locked. When the direction is changed, the wedge recess is reduced and the balls are free. This makes the outer member to rotate freely.

Fig: Free wheel unit

Advantages of free wheel

1. The engine can idle without disengagement of gears.
2. Without changing gears to neutral often, fuel economy is obtained.
3. There is less wear on transmission.
4. A Positive clutch is possible so that the unit can be put off action when required.

However, it is difficult, as brakes must be applied more effectively to stop the wheel while moving down a slop.

8) With the help of neat diagram explain the construction and working of sliding mesh gear box?

**Sliding Mesh Gear Box:**

It is the simplest type of gear box. The arrangements of gear are shown in figure, in natural position. The gear housing and bearings are not shown. The clutch gear is rigidly fixed to the clutch shaft. It remains always connected to the drive gear of the countershaft. Three other gears are also rigidly fixed to the countershaft (lay shaft). They are the second speed gear, first speed gear and reverse speed gear. Two gears are mounted on the splined main shaft which can be slid by the shifter yoke when the shaft lever is operated. These gears are the second speed gear and first and reverse speed gear. They can be connected to the corresponding gears of the countershaft. A reverse idler gear is mounted on another shaft and always remains connected to the reverse gear to the countershaft.

**Gear in neutral:**

When the engine is running and clutch is engaged, the clutch shaft gear drives the countershaft gear. The countershaft rotates opposite in direction of the clutch shaft. Note that in neutral position, only the clutch shaft gear is connected to the countershaft gear. Other gears are free, and hence the transmission main shaft is not turning. The vehicle is stationary.
First or low speed gear:

By operating the gear shift lever, the larger gear on the gear shift lever, the larger gear on the main shaft is moved along the shaft to mesh with the first gear of the countershaft. The main shaft turns in the same direction as the clutch shaft. Since the smaller countershaft gear is engaged with the larger main shaft gear, a gear reduction of approximately 3:1 is obtained. That is, the clutch shaft turns three times for each revolution of the main shaft. Further gear reduction in the differential at the rear wheels produces a still higher gear ratio, approximately 12:1, between the engine crankshaft and the wheels.

Second speed gear:
By operating the gear shift lever, the larger gear of the main shaft is demeshed from the first gear of the countershaft and then the smaller gear of the main shaft is meshed with the second gear of the countershaft. The main shaft turns in the same direction as the clutch shaft. A gear reduction of approximately 2:1 is obtained. The differential gear reduction increases this gear ratio to approximately 8:1.

**Third, top or high speed gear:**

By operating the gear shaft lever, the second gears of the main shaft and countershaft are demeshed, and then the second and top gear of the main shaft is forced axially against the clutch shaft gear. External teeth on the clutch shaft gear mesh with the internal teeth in the second and top gear. The main shaft turns with the clutch shaft and a gear ratio of 1:1 is obtained. The differential reduction produces a gear ratio of about 4:1 between the engine crankshaft and the wheels.
Reverse gear:
By operating the gear shaft lever, the larger gear of
the main shaft is meshed with the reverse idler gear. The reverse idler gear is always in mesh with the countershaft reverse gear. Interposing the idler gear between the countershaft reverse gear and main shaft bigger gear, the main shaft turns in the direction opposite to that of the clutch shaft. This reverses the rotation of the wheels so that the vehicle backs.

9) Describe a constant mesh gear box?

**Constant Mesh Gear Box:**

In this type of gear box, all the gears of the main shaft are in constant mesh with the corresponding gears of the countershaft (layshaft). Two dog clutches are provided on the main shaft—one between the clutch gear and the second gear, and the other between the first gear and reverse gear. The main shaft is splined and all the gears are free on it. Dog clutch can slide on the shaft and rotates with it. All the gears on the countershaft are rigidly fixed with it.

When the left hand dog clutch is made to slide to the left by means of the gear shift lever, it meshes with the clutch gear and top speed gear is obtained. When the left hand dog clutch meshes with the second gear, the second speed gear is obtained. Similarly, by sliding the right hand dog clutch to the left and right, the first speed gear and reverse gear are obtained respectively.
In this type of gear box, because all the gears are in constant mesh, they are safe from being damaged and unpleasant grinding sound does not occur while engaging and disengaging them.

10) What do you understand by epicyclic gearing? Describe an epicyclic gear box?

**Epicyclic Gear Box:**

In an ordinary gearing, the axes of the various gears are fixed, the motion of the gears being simply rotations about their own axes. In epicyclic gearing, at least one gear not only rotates about its own axis but also rotates bodily about the axis X X of the gear A.

The epicyclic or sun and planet type gear box uses no sliding dogs or gears to engage, but different gear speeds are obtained by merely tightening brake bends on the gear drums, which simplify gear changing.

Figure shows an epicyclic gear box. The compound gear ACE is mounted on a pin fixed to a wheel G. The compound gear is free to rotate on the pin. Gears A, C and E are meshed with three different gear B, D and F respectively, which are connected in turn to the
drums H, J and K. The drums H and J have brakes in their outer circumference and drum K is provided with a number of clutch plates. A hud is fitted to the flywheel spigot shaft N to which a number of clutch plates are attached. When the member m is pressed against the clutch plates, it engages the clutch, thereby connecting the shaft N to the output shaft P, directly. It is top speed gear.

To obtain low speed gear, disengage the clutch and apply brake on drum J, with the help of the gear change lever. This action locks the gear D, thereby decreasing the speed of gear B and hence that of the output shaft.
To obtain reverse gear, disengage the clutch and apply brake on drum M. This locks the gear F, thereby reversing the direction of rotation of B with respect to the input shaft. The speed of B is also reduced.

**Advantage of Epicyclic Gear Box:**

a) The planetary gears are in constant mesh and hence dog clutches or sliding gears are not used.
b) It provides a more compact unit operating about a common central axis, because the planetary gear operate within a ring gear with its external surface of cylindrical form.

c) External contracting hand brackets or multiplate clutches of relatively small dimensions are used for changing the gears.

d) Instead of having the load on only one pair of gears, it is distributed over several gear wheels.

e) Due to distributed loads, a greater area of gear tooth contact can be used.

The gear and gear housing are comparatively smaller is overall dimension.

11. With the help of a neat diagram describe the construction and working of an over drive?

Over Drive:

This device is used to rotate the propeller shaft faster than the engine shaft. Over drive is used to drive at a higher speed. With the help of this drive, engine life can be increased, fuel consumption can be improved, vibration and noise can be reduced. Moreover, additional gear ratios are made available. This unit is mounted just after the gear box. This is fitted to the top gear only. These are suitable especially for high power cars and can be operated manually and automatically. This consists of an epicyclic gear train. The principle of over drive is explained in the figure.

Fig: Principle of over drive
The main shaft of the gear box is connected to the planet carrier. A ring gear is attached to the outer race of the free wheel and then to the output shaft. The output shaft is cast integral with this free wheel. Suppose, the sun gear is locked to the gear box output shaft, the planet carrier driven by the gear box shaft, rotates around the sun gear. This carries the pinion gears. So the pinion gears walk around and drive the annulus gear, from where the drive to the output shaft is obtained. In this case, the ring gear rotates slower than the planet carrier. This arrangement gives a lower ratio than the direct drive.

In case, a direct drive is needed, sun gear is directly connected to the planet carrier. Now, the drive is taken from the gear box shaft the epicyclic gear train which is locked. Then, the train is transmitted through the free wheel to the over drive shaft. So, in the case of the drive, the output shaft can rotate faster than the gear box shaft.

Advantages

1. Engine life is increased.
2. Fuel economy is improved.
3. Vibration and noise are reduced.
4. Increased gear ratio is available.
5. Higher to gear ratio with greater fuel economy is provided.
6. Engine wear and loss of power reduces as the engine speed is lower.
7. Engagement and disengagement are easy.

12. Describe the working of a torque converter? How does it work as a fluid coupling?

A torque converter is a type of fluid coupling that uses a fluid to transmit torque from one shaft to another. Because a torque converter has a stator, which is not in the fluid coupling, it increases the torque ratio. However, at higher speed, the torque converter works as a fluid coupling, giving the gear ratio 1:1.

When the vehicle speed increases from slow to high, the need for mechanical advantages, decreases and the gear ratio of the torque converter gradually changes to that of a fluid coupling. It is so because the turbine speed gradually approaches the pump speed. This reduces the vortex flow so that less oil is sent back to the pump by turbine turbine and stator. When the turbine speed reaches a point
where the oil flow to the stator is no longer reflected, the stator starts to move with the rotating oil. This is the fluid coupling stage where the gear ratio becomes 1:1.

This action depends upon the throttle opening and vehicle load. At light throttle and steady load, the gear ratio may approach 1:1 at low speed. The torque converter automatically provides the effect of gear ratio as the need arises. Such conditions as hill climbing or rapid acceleration produce the change. In descending steep grades, torque converter is as effective as fluid coupling in transmitting torque to produce engine braking.

13. What is the function of propeller shaft in the transmission system of a vehicle?

Propeller Shaft:

https://ourmechanicalengg.wordpress.com/
This is an important shaft in the transmission system, by means of which drive is transmitted to the driving axle. The shaft power is to be transmitted to the rear wheels at different lengths and different angels. This shaft connects the transmission with the driving axle by means of Universal joints. This shaft also contains a slip joint which enables the shaft to vary it length. Thus the propeller shaft has to transmit the power from the engine end to the driven end in different vertical and horizontal planes. The propeller shaft is to withstand torisonal stresses, therefore, it must be well balanced. It should not whip when rotating at high speeds. This is made of a strong steel tube or shaft, with the main parts are shown in figure:

There are two types of propeller shaft.

1. Solid shaft and
2. Hollow tube

They are also called as Open type and Enclosed type.

Open type:

The open type is mostly used in commercial vehicles. This is simply a long shaft provided with the universal joint at each end. If the shaft is very long then it is made up of portions with an additional universal joint in between.
Enclosed type:

This is a solid shaft enclosed by a tubular structure which is called as torque tube. This torque tube is rigidly connected to the gear box casing by a ball joint. The torque tube is a rigid extension of the axle housing and prevents the twisting of the axle. Roller bearings are used to support the shaft inside the tube. Comparatively, the diameter of this shaft is smaller than the open type. Rivets are provided at both ends to prevent longitudinal movement.

Sliding joint:

When the rear axle moves up and down, its movement will be in a circle, with the front spring support at the frame as the centre. But due to propeller shaft motion, this centre is at the front universal joint, and these two centre joints go inside. Hence, the propeller shaft needs some arrangement to vary its length. This is accommodated by providing a sliding joint in the propeller shaft. This slip joint takes care of the difference in the length of the propeller shaft, due to its inclination when the axle moves up and down along with spring.

14. Explain the Hotch kiss drive and torque tube drive with neat diagrams

Hotch Kiss Drive:

This is the simplest one available for rear axle drive. The arrangement is shown in figure. Apart from taking the weight of the body, springs also bear the torque reaction, driving thrust and side thrust. There are two universal joints at the ends of the propeller shaft, which also carries a sliding joint as shown in the figure. The springs are rigidly supported in the rear axle. At the front end, the spring is fixed rigidly on the frame and a socket is used to support at the rear end. The spring deflection due to the torque reaction is shown in figure. So the torque reaction is taken up by the springs and the driving thrust is transmitted by the front half of the spring to the frame.
Fig: Hotch kiss drive
Advantages of hotch kiss drive:

1. The torque reaction, driving thrust, side thrust are all well supported by the leaf spring and universal joints.
2. Varying propeller shaft length can be accommodated without any inclination.
3. Provides comfortable ride.

TORQUE TUBE DRIVE:

In this case, the propeller shaft in enclosed in a hollow tube. The tube portion is rigid with the final drivel housing at one end and fastened at the other end by means of a flexible joint. Bearings are provide in the tube to support the propeller shaft. Only one universal joint is placed between the transmission and the propeller shaft. There is no sliding joint in this arrangement. The springs apart from supporting the body weight, take only the side thrust. The arrangement is shown in figure. Both ends of the springs are fitted by bolts and shackles. The axle casing is bolted at the centre of the springs. The front end of the propeller shaft is fitted in a cup with spherical fitting. The torque reaction and driving thrust are transmitted from the axle to the frame through the torque tube. It is to be noted that both the pinion shaft and propeller shaft move about the same centre of the spherical cup. Hence, there is no need for a sliding joint.
Radius rods:

The side-way forces are transmitted to the axle from the frame normally by the springs. The coil springs or torsion springs cannot be used with flexibility. In such cases, a transverse radius rod is provided parallel to the wheel axis. This is pivoted at one end to the axle and at the other end to the frame. This arrangement is shown in figure. the Rod “A” is placed above the axle and pivoted a the middle. The ball and socket joints are used a the end of the rods to allow for relative motion.

15) What are different types of Rear axle? Explain?

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

a) Semi-floating axle
b) Full floating axle

c) Three quarter floating axle

a) **Semi – floating axle:**

A semi-floating axle has a bearing located on the axle and inside the axle casing. It has to support all the loads as listed above. Therefore, it need to be of a larger size, for the same torque output, than any other type. The inner end of the axle is supported by the differential side gear. It is thus relieved of the job of supporting the weight of the car by the axle housing. The outer end has to support the weight of the car and take and thrust. The inner end of the axle is splined to the differential side gear. The outer end is flanged so that the wheel can be bolted directly to it. In some designs, the hub of the wheel is keyed to the outer end of the axle. The vehicle load is transmitted to the axle through the casing and the bearing, which causes the bending or shearing of the axle. The semi-flating axle is the simplest and cheapest of all other types and widely used on cars.

**Full floating axle:**

A full floating axle has two deep-groove ball or taper roller bearings, located between the axle casing and 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. Thus the axle is relieved of all strain caused by the weight of the vehicle on end thrust. It transmits only the driving torque. For this reasons, it is called full floating. The axle maybe removed from the housing without disturbing the wheel by removing the nuts. An additional advantage of this design is the ability to the vehicle even if it has a broken axle. This type of axle is more expensive and heavier than the other axle. It is usually fitted on commercial vehicles.
c) Three Quarter Floating Axle:

A three quarter floating axle has a 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 axle is keyed rigidly to the hub. Thus providing the driving connection and maintaining the alignment of the wheel. The inner end of this axle lies the same construction as that of the semi floating axle. Although the three quarter floating axle is more reliable but it is not as simple as the semi floating axle.
Fig. 26.7. Full floating axle.

Fig. 26.8. Three quarter floating axle.
16. Describe the construction and working of a differential?

When the Car is moving on a straight road both the rear wheels will be turning at the same speed. Suppose, the car takes a turn and both the wheels are rotating at same speed, it will be difficult for the return of the wheels to take place and the vehicle may get toppled if it is with solid rear axle. So, there will be a tendency for the wheels to skid. To avoid this difficulty, the outer wheels must be made to turn at a large radius. In the case of a solid rear axle, the inner wheel will slip causing rapid type wear, steering difficulty and poor road holding.

So, in order to avoid the above difficulties, some mechanism is needed to reduce the speed of the inner wheel, and increase the speed of the outer wheel during turning and bring back the wheels to rotate at the same speed. Thus, there must be a relative movement between the rear wheel, while taking a turn, with the torque transmitted being equal. Such an arrangement which provides the above requirements is known as ‘Differential’.

Type of Differentials

Normally the differential is of any one of the type.

1. Conventional
2. Non slip
3. Double reduction type

Principle of differential

The figure explains the functioning of differential. In figure a) when the shaft is moved in a straight ahead position, the bevel gears along with the shaft shall revolve at the same speed in the same direction, irrespective of the speed of the shaft. If as shown in the figure b, S-2, is held, stationary, then the right side bevel gear will not rotate. In this case, if the main shaft is assumed to move forward, the pinion rotates about its own axis and the left side bevel gear rotates faster, then in the previous case. Because in this case the left side bevel gear receives two different motions due to

1. forward pulling of the shaft as before.
2. rotation of the pinion about its own which is in constant mesh with the bevel gear.

Fig: Principles of differential

Suppose the right side bevel is allowed to slip on pinion wheel, then the left side bevel gear shall rotate at a lower speed than in the previous case.

Conventional type

Construction:
A differential consist of a casing in which the differential gears are assembled, as shown figure. The crown wheel or ring gear is attached to the rear axle shaft on bearings. The drive pinion is attached to the propeller shaft; two gears are attached to the end of the rear axle. Star pinions mesh with the sun gears. Two or four star pinions are provided. The star pinions are carried on pins. The pinions are free to rotate above their axes. The pin is held between the two parts of the cage. The sun gears and pinion are always in mesh and the sun gears are free to move inside the cage. The sun gears are positioned parallel to the ring gear, inside the differential cage. The assembly is supported on taper roller bearings. The entire arrangement may be made to rotate as a single unit, so that the axle shafts rotate at the same speed, when the vehicle is moving straight.

**Working of the differential:**

When the vehicle is moving straight, there is no relative movement among the differential gears. The cage and the gears rotate as a single unit. If we assume the cage to be stationary during turn, one sun gear will cause the other to rotate in the opposite direction.

That is to say, when the vehicle takes a turn, a binding force acts on the inner wheel. In that particular side the sun gear is held to rotate slowly with respect to the movement of the cage. This results in the star pinion rotating the outer side sun gear with a loss in the inner wheel speed and gain on the outer wheel speed. So the outer wheel moves faster. This rotation is super-imposed on the normal speed. Suppose, the vehicle is tuning towards the right, at that time, there will be a resistance to motion on the right wheel.
Due to the result of differential action, if the right wheel rotates at 'N' rpm, the left wheel rotates in the opposite direction with 'n' rpm. This arrangement makes the resultant speed of the left wheel as (N+n) rpm and speed of the right wheel as (N-n) rpm. But, the torque transmitted is equal to both the rear wheels.

UNIT – IV
1. What is meant by “wheel base”?
   Wheel base refers to the distance between the front and rear wheel axes of the car, when in straight a head position.

2. What is the advantage of the drop centre rim?
   The construction of drop centre makes the removal and mounting of tyre simple by squeezing the tyre on one side and dropping them in to the well portion.

3. What is the cause for more wear on one side than the others in the front wheels?
   Misalignment of the front wheels; causes an excessive amount of toe in or excessive camber to more wear on one side.

4. What is “wheel Tramp”?
   Wheel tramp refers to an uncontrollable motion of the front wheel due to violent vibration at high speed.

5. Why should not be brake drums be too close to the rim?
   Brake drums should not be too close, as the brakes heat is conducted to the tyre, more over if clearance is insufficient, ventilation is also restricted. Thus excessive heat may cause the tube to split.

6. What is meant by “anti-roll bar” in wheels?
   “Anti-roll bar” refers to a bar fitted between the wheels to resist cornering roll when the vehicle takes a corner. It winds up to resist cornering forces.
7. What is a tyre?

Tyre refers to the assembly of casing and tread mounted on a car wheel to provide an air cushion and contact with the road.

8. How is tyre constructed?

Tyre construction is a fabric caring with a rubber tread moulded on to it.

9. How can the alignment of the front wheels be checked?

Front wheels can be checked for proper alignment by first setting the wheels pointing straight ahead and then measuring at axle height, the distance between the wheel rims at the front and at the rear.

10. Define tie rod?

A rod which join the two front stub axles through an arm attached to it is called as tie rod.

11. What is (1) The track rod, (2) the drop arm?

The track rod is the rod that links the two arms attached to the stub axles.

The drop arm is a short links conveying the motion of the steering gear to the push rod.

12. What are the five important angles in steering?

Caster
Camber
Toe-in
Steering axle inclination
Toe-out

13. What is the purpose of toe-in?
1. To steady the steering and to ensure rolling of front wheels.
2. To prevent side slipping
3. To prevent excessive turn in tyres.

14. Why steering axis inclination is provided?

1. Reduce the steering effort
2. Provide stability to steering
3. Reduce the tyre wear.

15. What are the causes of wheel wobble?

- Wear (or) improper adjustment in the linkage.
- Worn out ball joints.
- Loose wheel bearing.

16. What are the causes of wheel wobble?

Excessive play in the steering linkage.
Wear or play in the wheel bearings and stub axle pins.
Incorrect tyre pressure.

17. Why do vehicles pull to one side?

Incorrect tyre pressure
Bent shock absorber
Improper setting of steering geometry

18. Why do vehicles wander on either side?

Unequal inflation of tyre.
19. What are the causes of hard steering?

Tight steering gear and linkage
Uneven tyre pressure
Friction in steering gear and linkage.
Improper front-wheel alignment.

20. Name the parts requiring lubrication on the front axle and steering gear?

- Stub axles
- Track rod
- Steering box
- Hubs unless placed with grease require lubrication.

**Suspension**:

21. What is pitching in the suspension system?

Pitching is a rocking action about a transverse axis through the vehicle, parallel to the ground. The front suspension moves out of phase with the rear, experiencing the rocking effect due to pitching.

22. What is bouncing in the suspension system?

Bouncing is a vertical vibration of the complete body when the vehicle crosses an up and down surface of road.

23. What is the difference between conventional suspension and independent suspension system?
In conversional types, wheels are fitted on the beam type axles which are attached to the chassis through load spring.

In independent system, there is no axle beam suspension for each wheel is of an independent in it and free from the effect of one another.

24. What is independent suspension normally applied to the front wheels and not to the rear wheels?

In independent suspension is used in the rear wheels additional universal joints are necessary in order to transmit the power to the wheels which more independently of each other.

25. What are the advantages of rubber suspension?

- It can store more energy per unit weight that the steel tyre.
- It has good vibration damping properties.
- Squeaking is not present unlike in the steel tyre.

26. What is a panhard rod (or) track bar?

A panhard rod is a bar (or) tube running from one side of the axle to the frame on the other side of the vehicle. It helps the leaf spring in keeping the axle entered under the body during turning a corner.

27. What are the main functions of the shock absorbers?

(i) Single acting     (ii) Double acting.

28. What are the main functions of the shock absorbers?

- To control the quick bouncing of the wheel.
- To control the slow bouncing of the body in the suspension spring.
- To keep all the four wheels on the road during turn at high speed
29. What are the nominal requirements of a body?

- Be light in weight and strong
- Be able to stand the fatigue
- Have even distribution load.
- Be vibration free
- Have maximum luggage carrying capacity
- Be streamlined to have the minimum resistance
- Be cheap and easy to repair.

**Brake System:**

30. What is the function of a braking system?

The function of brake is to reduce the speed, to stop the moving vehicle within a minimum possible time and a minimum possible distance and to hold the vehicle.

31. List fire factors that contribute to brake effectiveness?

1. Area of brake lining
2. Amount of pressure applied to brake shoes
3. Radius of brake drum
4. Radius of Car wheel
5. Co-efficient of Friction of braking surfaces.

32. Give the classifications of brakes

(i) Mechanical brakes
(ii) Hydraulic brakes
(iii) Air brakes
    Power assisted Brakes
33. What is an internally expanding brake preferred in automobile?

   The brake effect is gradual, protection and care is possible and easy. It is convenient to fasten brake lining on brake shoes to increase the coefficient of friction so as to prevent the wear of the metal.

34. What is service brake and auxiliary brake systems?

   Service brake-A control device which acts on the wheels and is operated by a foot pedal is the service brake system. Auxiliary Brake- It is a control device installed on the gear box main shaft. It is operated by a lever under hand control.

35. What is “Brake compensation”?

   A process of ensuring equal braking effect at all the wheels inspite of unequal wear of lining is known as Brake compensation.

36. What are the minor and major adjustments of brakes?

   Minor adjustments –refers to the adjustment of brake shoes to compensate lining wear without removing the wheel. Major adjustment is installation of new shoes or relining the old shoes.

37. List four factors that tend to increase brake temperature?

   Load on vehicle.
   Speed of vehicle
   Maladjustments of brakes.
   Unbalanced braking are the factors that increase brake temperature.
38. What is the function of disc brake and advantages?

A disc brake consists of a rotating disc and two friction pads which are actuated by four hydraulic wheel pistons contained in two halves of an assembly called caliper.

39. Why are Hydraulic brakes popular used in vehicles?

Hydraulic brakes are preferred as they are more efficient and need only less pedal pressure, more over, braking pressure is distributed to all the wheels.

40. Name various components of the hydraulic braking system.

(i) Brake pedal 
(ii) Master cylinder 
(iii) Brake pipes and shoes. 
(iv) Wheel cylinders  
  Brake drums 
  Brake shoes 
  Brake linings 

41. How does the hydraulic brake function?

When the foot pedal is pressed, the brake fluid in the master cylinder is forced through a pipe line to the individual wheel cylinders. The movement of the brake fluid in the wheel cylinder operates the expander mechanism to move the brake shoes against the drum.

42. What are the qualities must be good hydraulic brake fluids have?

The hydraulic brake fluid must not swell (or) soften the rubber parts used  
Brake fluid must not vapourize at high temperature in actual service.  
It must acts as lubricant
43. Why does the brakes pedal go down?

(i) Worn out brake lining
(ii) Leakage of air bubbles
(iii) Presence of air bubbles
Misaligned linkage.

44. Why are hydraulic brakes naturally “Self-equalizing”?

In hydraulic braking system all the brake shoes are forced to contract the drum by the pressure initially built up well before increase of the pressure in the system. Thus, all the wheel brakes are forced to act simultaneously. So hydraulic brakes are self equalizing.

45. What are the main parts of the air braking system?

- Air filter
- Air compressor
- Unloaded valve
- Reservoir (or) airtant
- Brake valve
- Diaphragm unit of brake chamber

46. What is the function of the brake lining?

- To increase the co-efficient of friction
- To prevent wearing away of the metal.

47. What is the difference between leading and trailing shoes?

Leading shoes drags along the drum and creates more friction against the drum, where as trailing shoes to more away from the drum.
48. What are the materials added to the brake shoes to effective?

Zinc, Brass, Copper, Graphic, Ceramic products may be added to the asbestos lining to give better gripping action.

49. What is meant by power brake?

Brakes operated by power other than physical effort applied at brake pedal is known as power brake. The power may be exerted by air pressure, engine vacuum (or) electrical energy.

50. What is meant by servo brake?

Servo brake is one in which the pedal effort is assisted mechanical (or) vacuum effect.

51. What are the different sources for additional effort to serve systems in power brakes?

- The momentum of the vehicle itself.
- Vacuum in a reservoir, obtained from the induction manifold.
- Oil under pressure supplied by an engine driven pump.
- Air under pressure supplied by a compressor, driven by the engine.

52. What are the main designs of power brake?

Generally, there are two designs of power brakes. One constitutes the combination of vacuum and hydraulic units in one assembly which replaces the master cylinder. In another design, the power unit is linked to the brake pedal of a conventional hydraulic brake system.

53. What is known as HYDROVAC?

Hydrovac is a combined hydraulic and vacuum power braking system, utilizing the vacuum from the intake manifold as an operating source.
54. What methods are used to ensure proper balancing of brakes?

1. Brake testing machines to indicate equal distribution of braking on each wheel
2. Applying the brakes hard, on a smooth road and noting which wheel skids.

55. What is an “anti-lock” system in brakes?

An anti lock system consists of a sensor to detect incipient wheel locking. This system is also provided with an arrangement for relieving momentarily the hydraulic pressure on the brakes to prevent locking before its application.
PART - B

1) What are the different types of wheels? Describe their constructions?

Type of Wheels:
The wheels are usually of the following types:
Disc Wheel: This type of wheel consists of a steel rim and a pressed steel disc. The rim is rolled section, sometimes riveted but usually welded to the flange of the disc. The disc performs the function of spokes. The disc is frequency dished to bring the point of ground contact under the large wheel bearing. The wheel assembly is bolted to the brake drum. The hub cap or cover is usually held in position by spring clips attached to the disc. The disc is often perforated with slots near the rim, which acts as fan to blow air on the brakes. A hole in the rim serves to accommodate tube valve. This type of wheel is simple, cheap and robust in construction. It is most commonly used in heavy motor vehicles-cars, buses, trucks, tractors.

a) Wire wheel:
This type of wheel consists of a separate hub connected to the rim with a number of wire of spokes. The headed inner ends of the spokes fit in the hub holes and the threaded outer ends fit in the rim holes, where mushroom-headed tubular nuts are screwed through the rim holes to tighten the spokes. All the spokes must be of correct length and at correct tension to hold the rim, centrally around the hub. The spokes do not stick straight out as radii from the hub, but alternate spokes are screwed to slope forwards and backwards towards the rim. This arrangement or spokes serve special purpose of the wheel. The forward-sloping spokes absorb breaking torque and the reward sloping spores convey driving torque. The holes in the hub are arranged in inner and outer rows so that one set of spokes slope towards to the rim form the outer row of the hub and the other set slopes outwards to the rim from the inner row of the hub. These sideways inclinations of the spokes hold the wheel upright against cornering loads and side thrusts. A rubber chafing band is fitted in the well of the rim to keep tube touching the spoke nuts. The tension of the spokes may be tested, when the wheel is free of load, by tapping them, which should produce an equal ring from each spoke. The wire wheels allow free circulation of air around the brake drum. They are lighter in weight than other types of wheels and used in light motor vehicles-racing cars, scooters and motor cycles.

c) Split wheel:

The split wheel is made in the from of two dishes which fit back to back and are clamped by a separate outer ring of studs and nuts. The flanged of the discs thus gives a seating for the type of clamp on the beads. A thick section rubber ring is sometimes fitted in the gap between the tow beads. The main advantage of split wheel is that the type may be easily taken out of the wheel by unscrewing the nuts and separating the two discs.

d) Heavy vehicle wheel:
The heavy vehicle wheels are made in the same way as the disc wheels but much thicker plate is used. To lighten the wheel and also to increase air flow to the brake drum, large holes are made around the disc. The wheel nut recesses are usually machined instead of being embossed. In the case of twin rear wheels, the inner wheel may have a longer valve stem to reach through the outer wheel for case of inflation and pressure check.

2) Where the tubeless and tube tyres?

Tyres:

The tyre is mounted on the wheel rim. It has to carry the vehicle load and provide a cushioning effect absorbing flexing actions. It must produce a minimum noise, while the wheel is turning on the road. It resists the tendency for the vehicle to oversteer or turn into the blend while cornering. It should have good grip while accelerating and breaking the vehicle on both the dry and net roads.

Types of Tyres:

a) Tube tyre:

It is a traditional type. It encloses a tube in which air is forced to a high pressure as a cushioning medium. The outer portion of the tyre which rolls on the road is made of synthetic rubber and is called tread. At the inner edges, beads are formed by reinforcing with steel wires. The beads act as strong shoulders, for bearing against the wheel rim. Rayon cords are formed into a number of piles. Where the beads and cords give strength to the tyre, the treads provide resistance against slipping and thicker surface at the outer periphery.

b) Tubeless Tyre:

Tubeless tyre does not enclose the tube. The air under pressure is filled in the tyre itself. The inner construction of this tyre is almost the same as that of the tube tyre. A non-return valve is fitted to the rim through which the air is forced inside the tyre.
The tubeless tyres are lighter and run cooler than tube tyre. The main advantage of a troubles tyre is that it retains air for a long period even after being punctured by nail, provided the nail remains in the tyre. Both the tube tyre releases the air almost immediately after being punctured. Also, any hole in the tubeless tyre can be repaired simply by rubber plugging.
Ordinary punctures can be repaired without removing the tyre from the wheel. It can be retreated in the same manner as the tube tyre.

The tubeless and tube tyres are called pneumatic tyres, in which the air is forced inside the tube itself or in a tube which is fitted in the tyre. In both the cases, air is a cushioning medium. But in solid tube, it is not so. Neither the air is forced inside the tyre and nor the tube is enclosed inside it. The tyre is completely solid and is mounted on the wheel rim. It is fitted on the wheels rim, it runs for a life long time. Because, it is a heavy tyre and does not provide cushioning effect, it is not used on automobiles. It use is limited to the children’s tricycles.
Ever since man invented the wheel, things began to move. Centuries later John Boyd Dunlop invested the pneumatic tyre and wheels moved faster and better. And then Dunlop India brought tyre manufacture to India in a big way. With a progressive record of first in the service of India’s transport, industry, agriculture, defense and exports. Dunlop leads the way.  

3) Give the construction of a cross ply tyre?

The tyre construction is divided into two classes:

a) Cross ply tyre construction
b) Radial ply tyre construction

In the cross bias tyre construction the alternate layers of cords run in opposite diagonal directions. It is also known as cross bias tyre construction. These types of tyres have better wear and road holding characteristics. But they must not be fitted on the front wheels only. Fit radial tyres all round, or use cross play on the front and radial ply tyres on the rear wheels, otherwise the cornering characteristic will be seriously impaired.
In Radial ply the tyre construction, the cords run radially from head to bead.

The various components of the tyre are as follows:

**Tread:**

The shoulder to shoulder width of the tyre represents the tread. Natural as well as synthetic rubbers are used for the tread of the tyre. The natural rubber helps the tyre to start cooler during running.

**Breaker:**

The two top plies of the tyre are referred to as breakers. They are widely spaced as compared to other plies. These plies help in spreading the shocks received from the road.

**Casing:**

The tyre casings are made up of layers of cord impregnated with rubber. The number of layers of cord varies according to the use of tyre. Motor car tyres usually have 4 to 6 plies. Heavy-duty truck and bus tyres may have up to 22 piles whereas for earthmoving machinery the tyres may have up to 34 plies.
Side walls:
The side walls are of rubber compound which serve as protective covering to the casing. A tyre may have a black or white side wall. Both the side walls have the same performance of the tyre.

**Beads:**

Coil of wires represent the beads. These wires are of high-tensile steel which are built in the edges of the tyre in order to give strong edges to press against the inner edge of the rim.

4. Explain the steering system in an automobile with neat sketches?

Gear components are enclosed in a steering gear box.

The steering gear box is classified as:

1. Worm and Wheel (Cam and double lever steering roller box)
2. Worm and sector arm wheel.
3. Screw and nut
4. Cam and lever and
5. Rack and pinion.

By turning the steering wheel, motion is transmitted through the steering shaft to the steering gear box. A drop arm which is splined to the steering gear box, rocking at one end, is connected to the drag link by a ball joint at the other end. This drag link transmits the motion to the steering arm and steering knuckle. The track rod which is attached to the steering arm by ball joints turns the other wheel.

5. Explain the terms caster and Camber?

**Caster**

**Purpose**

1. To obtain directional control of the vehicle by making the front wheels to maintain straight-ahead position or return to straight-ahead position out of a turn.
2. To offset road crown: This is the backward tilt of the king pin from the axle at the top. This shown in the figure. The main purpose of the caster angle is to make the driver to have maximum steering, to have directional stability to travel straight ahead. This is achieved by the fact that the projected axis of the king pin strikes the road ahead of the contact point of the tyre. This arrangement has a tendency to drag the wheel behind it providing the vehicle directional stability. The backward tilt from the vertical as shown in the figure is called positive caster and in contrast, the forward tilt in the same plane is called negative caster. For effective result, the Caster will be about three degrees.

Figure Caster

Suppose the caster is not provided and the axle is set horizontal with the king pin vertical, the weight of the vehicle would be directly acting above the contact point. In this arrangement, the wheels would be wandering and the vehicle would lack steering stability. By providing caster or forward tilt of the axle, wheel wandering is prevented and vehicle load is made to move ahead of the contact point causing the run to be straight even after a turn.
Camber

This is the outward tilt of the front wheels from the vertical plane at the top. This tilting is called ‘Positive Camber’. In case of Negative Camber, the load is allowed to act through King pin directly down thereby relieving any bending action of the pivots.

Purpose

1. To bring the road contact of the tyre more nearly at or under the point of the load.
2. To provide easy steering by allowing the vehicle weight to be carried by the inner wheel bearing and spindle.

Effects of incorrect camber

1. Excessive wear on wheel bearings.
2. Excessive wear on ball joints.
3. Excessive wear on one side of the tyre tread.
4. Excessive uneven camber causes vehicle to pull on one side.
5. Negative camber leads to inside wear and positive camber leads to outside wear.
Camber angle should not exceed more than two degrees. It is understood that tyre life will be maximum when the camber angle, in running condition, is zero with medium load.

Suppose no camber is provided and the front wheels are perpendicular to the outer end, the load of the wheel would be acting on the outer end of the spindle and hard steering would be experienced. If the wheels are cambered, the load will tend to bring the wheels near the vertical position, when the vehicle is loaded. Refer to the figure.

6. Explain no terms Toe-in and Toe-out?

Toe - in

The toe-in refers to as the turning-in of the front wheels from the straight ahead position. The plan of wheel is shown in the figure. It is clearly seen that the distance between the front wheels is lesser at A than at B. This amount should not exceed 3 milli-meters. Because
of this, the wheels will have the tendency to move perfectly straight ahead. The main purpose of the toe-in arrangement is to stabilize steering during running, to prevent side slip and excessive wear on tyres.

Figure Toe – in

There is a tendency for the toe-in vehicle to run inward. At the same time, when the wheels are positively cambered, they will have a tendency to roll outward. Thus, when toe-in and camber are properly adjusted, the wheel will roll in a straight line. When the camber angle is greater, then toe-in adjustments will be small and vice-versa.

Toe-out

Toe-out on steering geometry refers to the difference between the front wheels and the chassis frame during turning. The toe-out on turns is explained in figure. The difference in the angles of the wheels during turning is obtained by setting the steering arms obliquely so that they point inward to the central line of the car thus providing toe-out. The inner wheel must toe-out more than the outer wheel.
7) Briefly describe the live and dead front axles?

**Front axles:**

The front axle is used to carry the weight of the front part of the vehicle as well as to facilitate steering and absorb shocks due to road surface variations. It must be right and robust in construction. It is usually a steel drop forging having 0.4% carbon steel or 1-3% nickel steel. It is made of I-section in the centre portion, while the ends are made either circular or elliptical. With this construction, it takes bending loads due to the load of the vehicle and also torque due to braking of the wheels. To keep the low chassis heights it centre portion is given a downward sweep. The different components of the front axle are the axle bear, stub axle, swivel pin and track rod.

**Types of Front Axels:**

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Usually there are two main types of the front axles:

a) Live front axle
b) Dead front axle

The front axles are usually dead axles because they do not rotate, in contrast to the live axles that they are used in the rear axle to transmit power to the rear wheels. A live front axle, as compared to the dead axle, has the additional function of transmitting the driving power taken from a transfer gear box to the front wheels having a different swiveling mechanism. The live front axles although resembling the gear axles have some difference at the axle half shaft ends where the wheels are mounted. The dead front axle has sufficient rigidity and strength to transmit the weight of the vehicle from the springs to the front wheels. The ends of the axle beam are shaped suitably to assemble the stub axle. In order to accommodate a swivel pin connecting the stub axle portion of the assembly, the ends of the beam are usually shaped either as a yoke or plain surface with drilled hole.

A typical front axle with stub axle is shown in figure. Another front axle assembly with stub axle and track rod is shown in figure shows front axle components with steering linkage. The wheels are mounted on the stub axles which are often pivoted. From the sub axle the inclined steering arms connected to the track rod ends, and a third steering arm is attached to the drag link. Some vehicles have the drag link placed transversely instead of in the fore and at position in order to allow a more compact vertical design. It is often used in independent wheel suspension system. The drag link connects to the steering linkage to the drop arm of the steering box.
8. Explain all type of steering Gear box with neat diagrams?

**STEERING GEAR BOX**

**Worm and double roller steering box**

A simple sketch of this type is shown in the figure. A worm gear is attached at the outer end of the steering shaft. At the inner end, a drop arm is fitted. When the steering wheel is turned, the drop arm turns the worm gear. This causes the double roller to move in an arc and makes the cross shaft rotate. The roller moves up and down in the worm giving a twist to the drop arm shaft. Then the drop arm shaft turns the front wheels through linkages.
Cam and double lever steering gear box

Figure Worm and double roller steering

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The cam-and-lever steering use one or two lever studs fitted in taper roller bearings. When the worm in the form of a helical groove rotates the studs or pegs follow along with it. This imparts a turning motion to the pitman arm shaft. The arrangement is shown in the figure.

Figure Cam and lever steering

At the lower end of the steering shaft a helical groove is formed, which acts as a cam. The drop arm shaft consists of two pegs acting as levers. Here the helical groove acts as a cam. The helical groove engages pegs. The drop arm is rigidly fixed with the pin lever.
When the steering shaft is rotated, the twin levers move up and down in the helical groove. This causes the drop arm shaft to rock. This motion result in turning the Stub Axles.

Figure Single lever

The gear box for single lever arrangement is shown in figure. The steering shaft (1) carries the cam which is in the form of a worm (8). The cam is supported on ball bearings (5). The lever (2) is positioned in the cam by means of a stud. (7). The entire arrangement is housed through a bush (6) within a casing (3) provided with a oil plug (9) to pour in oil. Maximum mechanical advantage can be obtained at straight ahead position and lesser advantage when the gear is near to the end position.
Rack and pinion steering

This type of steering gear is widely used in cars with independent front suspension. This gives a gear ratio of 17.5 : 1 in maruti – 800.

This is a very simple arrangement of steering mechanism made up of steering rack and a pinion gear. There is a rack (1) placed in a tubular casing which is supported on the frame. The ends of the rack are connected to the track rods (3). Ball and socket (4) are made use of in this connection within the rubber boot (5) as dust proof. The pinion shaft is placed in the bearings fitted in the casing. The pinion (2) will be in constant mesh with the rack (1). There is an adjusting screw for clearance adjustment. The pinion is attached at one end of the steering shaft. So, when the steering wheel is rotated, the pinion moves the rack in either direction. The to and from movement of the rack is used to turn the wheels through the tracks. Refer figure. A universal joint (5) provided at the bottom of steering shaft helps to mount the steering box centrally. Spring pads (6) are provided beneath the rack to reduce backlash.

Figure Rack and pinion

A re-circulating ball gear has a driving fear and a driven gear. The driving gear is a worm gear with spiral threads. The driver gear is a sector gear, connected to the pitman arm.
This is a screw and nut type of steering gear box. A simplified arrangement is shown in the figure. As shown in the figure, the lowest end of the steering shaft carries a screw and a screw nut. The outer surface of the nut is provided with a threaded potion engaged with the sector wheel. The sector wheel is connected to the drop arm through cross shaft. The inner threads of the nut and the thread form of the screw are shaped as semi-circular grooves or a re-circulating ball race is provided between the nut and the screw.

By turning the steering wheel, the balls in the worm, roll along the grooves. This movement causes the nut to travel along the worm. The balls are re-circulated through the return guides shown. The up and down movement of the ball nut causes the wheel sector to turn to the required angle. The wheel sector actuates the drop arm and thereby the link rod. This results in the steering of the front wheels.

9. Explain the construction and work principle of power steering?

POWER STEERING

The main objective of power steering is to reduce the driver’s effort in steering. The system may employ electrical devices, pneumatic and hydraulic pressures.

In this mechanism, in addition to the manual operation of the steering wheel, external power is also used to assist the operation. The assisting power may be obtained by compressed air, electrical system or hydraulic pressure. Hydraulic pressure is mainly used to supply this extra power. Power steering is basically power assisted steering, in which there will be an arrangement to boost the steering wheel turning. The booster does most of the steering operation. The construction of the power steering is in such a way that, even when
there is failure in the power source the vehicle can be operated with the help of the conventional steering. There are two types of power steering (1) Integral and (2) Linkage booster type. Both make use of hydraulic pressure produced by a pump driven by the engine.

**Principle**

The slight turning of the steering wheel actuates a valve. This movement makes the fluid from a reservoir to enter into the appropriate side of a cylinder, under pressure. This pressure is applied on one side of a plunger suitably, to operate the steering linkage.

For straight ahead position, the spool valve is held in a centre position with the help of springs. At this stage oil flows to both sides of the power cylinder piston, at the same pressure. So there will not be any relative movement in the power cylinder.

A very popular linkage booster type is shown in the figure. There is a power piston cylinder attached to the relay rod. The piston is held stationary with the piston rod as shown in the figure. The Pitman arm is attached to the shaft of a spool valve which acts against some fluid pressure.
Figure Power Steering

The pump supplies the oil under pressure form tank through a spool valve to either side of the piston as shown in the figure. When the steering wheel is positioned for left turn, the piston arm moves towards left and moves the spool valve to overcome the pressure of the fluid. As the valve body moves towards right, the oil pressure is transmitted to the right hand side of the power cylinder piston, and the left side of the oil pressure is transmitted to the reservoir. This makes the cylinder housing to move towards right, since the piston is held stationary. The movement of the power cylinder is transmitted to the relay rod arms. The movement of the tie-rod, makes the wheel turn towards left.

10. What are the function of suspension in a motor vehicle? What are requirements of Suspension system?

Functions of suspension system:

a) To prevent the road shocks from being transmitted to the vehicle frame
b) To preserve the stability of the vehicle in pitching or rolling, while in motion.
c) To state guard the occupants from road shocks.
d) To provide good road holding while driving, cornering and braking.
e) To maintain proper steering geometry.

Requirements of a suspension system:

a) Minimum deflection consistent with required stability.
b) Comparability with other vehicle components type, frame, wheel base, steering linkage.

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1) Minimum wheel loop.
2) Low maintenance and operating costs.
3) Low initial cost.
4) Minimum weight
5) Minimum tyre wear

11) Briefly explain the types of suspension springs?

**Types of suspension springs:**

- a) Leaf springs
- b) Coil spring
- c) Torsion spring
- d) Air bags
- e) Rubber spring

**Leaf spring:**

Leaf spring consists of a number of leaves, made of steel plates, of increasing lengths from the centre. All the leaves are clamped by a centre bolt at the centre, and side clamps at the sides so that the leaves are in position. Main leaf is the longest one having bent ends, called the spring eyes. The spring eye is connected to the frame by a shackle. The center portion of the spring is connected to the front axle by a U-bolt.

Leaf springs re of the following types:

- a) Semi-elliptical spring
- b) Quarter elliptical spring
- c) Three quarter elliptical spring
- d) Transverse spring
- e) Full elliptical spring
- f) Platform type spring

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Semi-elliptical springs are usually used in all the vehicles. Particularly in trucks, semi-elliptical springs are fitted in front and rear axles. But in cars they are fitted on the rear axle only and the independent suspension is fitted on the front axle. Semi-elliptical springs are cheaper and require less repairing. They increase the range of spring action and last for a long time.

Quarter elliptical springs were used in old small cars, like Chrysler cars. This type of spring consist only a quarter portion of the full elliptical spring and fitted with the frame by bolts.

Three quarter elliptical spring is the combination of semi-elliptical and quarter elliptical springs. This type of spring was used in old cars.

Transverse spring is just like the semi-elliptical spring but inverted in shape. One end of the spring is joined with chassis frame by shackle, and the other end with the axle. It is also fixed with frame by bolts at the centre.

Fully elliptical spring consists of two semi-elliptical springs joined together oppositely. This type of spring was used in old cars. They do not maintain correct axle alignment.

Platform type springs consists of two semi-elliptical springs. They are fitted with chassis frame by shackle at one side and the other side is fitted with an inverted semi-elliptical spring. In this arrangement, the weight of the car is divided on the three points.

**Helper spring:**

Helper spring is just like a semi-elliptical spring but without eyes at the ends. It is fitted with the main springs particularly on the rear axle of the truck to carry heavy load. The ends of the helper spring touch the brackets fitted on the frame when the truck is heavily loaded.

**Coil Springs:**

Coil springs are made of spring steel. These are described with the independent suspension system.

**Torsion spring:**

Torsion spring is also used in independent suspension system.
Air bags and rubber springs are used in foreign cars. Air suspension, hydraulic suspension and hydrogen gas suspension systems are also used in foreign vehicles.

12) Why are mechanical brakes used in parking and emergency?

**Mechanical Brakes:**

In a motor vehicle, the wheel is attached to an auxiliary wheel called drum. The brake shoes are made to contact this drum. In most designs, two shoes are used with each drum to form a complete brake mechanism at each wheel. The brake shoes have brake linings on their outer surfaces. Each brake shoe is hinged at one end by an anchor pin, the other end is operated by some means so that the brake shoe expands outwards-the brake linings come into contact with the drum. Retracting spring keeps the brakes shoes into position when the brakes are not applied. The drum encloses the entire mechanism to keep out dust and moisture. The wheel-attaching bolts on the drum are used to contact wheel and drum. The braking plate competes the brake enclosure, holds the assembly to the car axle, and acts at the base for fastening the brake shoes and operating mechanisms. The shoes are generally mounted to rub against the inside surface of the drum to form an internal expanding brake.
When the brake pedal is pressed, the cam turns by means of brake linkage. When the cam turns, the shoes expand outwards against the drum. A toggle lever is also used for the same purpose, as shown in figure. The brake linings rub against the drum and thus stop its motion. The entire mechanical linkage between the brake pedal and the shoes operates to transmit pedal force to the brake shoes, and to multiple that forces through leverage to produce effective braking forces against the drum.

13) Briefly describe the construction and working of hydraulic brakes?

The hydraulic brakes are applied by the liquid pressure. The pedal force is transmitted to the brake shoe by means of a confined liquid through a system of force transmission. The force applied to the pedal is multiplied and transmitted to all the brake shoes by a force transmission system. This system is based upon Pascal’s principle, which states that “the confined liquids transmit pressure without loss equally in all directions”.

consists of two main components-master cylinder and wheel cylinder. The master cylinder is connected by tubing to the wheel cylinders at each of the four wheels. The system is filled with the liquid under light pressure when the brakes are not in operation. The liquid is known as brake fluid, and is usually a mixture of glycerin and alcohol or caster oil, denatured alcohol and some additives.
Each wheel brake consists of a cylinder brake drum which is mounted on the inner side of the wheel and revolves with it and brake shoes which are mounted inside the brake drums and do not rotate. The shoes are fitted with a heat and wear resisting brake lining on their surfaces.

The brake pedal is connected to the master cylinder piston by means of a piston rod. When the brakes are to be applied, the driver depresses the pedal, the piston is forced into the master cylinder, this increasing the pressure of the fluid in the master cylinder and in the entire hydraulic system. This pressure is conducted instantaneously to the wheel cylinders on each of the four brakes, where it forces the wheel cylinder pistons outwards. These pistons, in turn, force the brake shoes out against the brake drums. Thus the brakes are applied.

When the driver releases the brake pedal, the master cylinder piston due to the return spring pressure, and thus the fluid pressure in the entire system drops to its original low value, which allows retracting springs on wheel brakes to pull the brake shoes out of contact with the brake drums into their original positions. This causes the wheel cylinder pistons also to come back to their original inward position. Thus, the brakes are released.

14. What is the function of master cylinder in hydraulic brakes?

Master Cylinder

The master cylinder is the fluid reservoir for the brake and is operated by the brake pedal. Master cylinder connects the individual wheel cylinder as shown in the figure. Through hydraulic transmission by steel pipe lines and flexible hoses, even when the brakes are in released position there will be a small pressure maintained in the pipe lines. This prevents air entrance. When the brake pedal is pressed, the hydraulic pressure in the master cylinder is forced to the individual wheel cylinders moving out the two pistons in the opposite direction. The pistons are connected to the brake shoes as shown in the figure. This expands the brake shoe.

When the brake pedal is released, the master cylinder piston returns to its original position with the help of a return spring. This makes the hydraulic pressure in the entire system get reduced or released. This reduction in pressure allows the retracting springs to pull the brake shoes from contact with the drums. This makes the wheel cylinder piston also to come back.

Master cylinder is the main part of the hydraulic system. The main objectives of this system are as follows:

1. Hydraulic pressure will operate the brakes.
2. The volume of the brake fluid in the drum is maintained.
3. It acts as a pump to bleed air out of the system.

Construction

The construction details are shown in the figure. It consists of two sections (1) Reservoir. (2) Main cylinder.
The fluid is filled into the reservoir through the tap hole. The tap hole is closed with a plug which contains an air vent. The bottom portion is called main cylinder. This consists of a piston, primary and secondary rubber cups, coil spring, check valve and a rubber seat. The reservoir and the main cylinder are connected through two holes, which are known as main port and compensating port.

The operation of the piston in the main cylinder is by the brake pedal though some linkages. When the brake pedal is pressed the piston inside the main cylinder moves against the spring action and forces the fluid out though the check valve. However, a fluid pressure is built up by this movement in the brake system. The fluid pressure is uniformly carried out to the portion in the wheel cylinder. As explained earlier, the outward movement of the wheel cylinder pistons expand the brake shoes.

**Action in the master cylinder**

To understand in detail what is actually happening in the master cylinder during the application of the brakes, assume that, brake pedal is applied slightly. This braking effort through linkages moves the piston, and rubber cup towards the outlet. As soon as the compensating port is covered by the rubber cup, pressure is built up in the cylinder. This pressure makes the fluid to pass through a check valve into the system. The cylinder pressure is proportional to the pressure exerted.

Similarly, when the brake pedal is released slowly, the rubber cup returns to the position in the released direction. Due to the release of pressure, the fluid returns from the wheel cylinder in to the main cylinder. This makes the outlet check valve to push back off its seat. Again, the oil may be passed into the receiver.

**15. Sketch the air brake system of a motor vehicle, and describe how it works?**

**Air Brake**

In this system, the operation of the cam in the wheel cylinder is by means of air pressure. The air pressure is obtained by air-compressor driven by the engine. There are separate brake chambers for separate cams. The brake chamber is connected with the air void. A brake valve, operated by foot pedal, controls the pressure that affects the brake chamber. A layout of the air brake system is shown in the figure. The air brake system consists of the following parts.
1. **Air Compressor**: This is of a reciprocating type. This is connected to the engine shaft itself.
2. **Governor or unloader valve**: This is a type of safety valve that prevents excessive pressure in the reservoir.
3. **Reservoir**: It is a steel pressure vessel for accumulation of compressed air.
4. **Brake valve**: This is a control valve operated by the brake pedal.
5. **Brake Chamber**: This is a housing which encloses a diaphragm with a link rod to operate the cam shaft. The diaphragm divides the chamber into two parts, the other side of the link rod being air tight. Refer figure.

**Operation**

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When the foot pedal is pressed, air pressure acts up on the diaphragm of the brake chamber. Because of the difference of pressure on either sides the diaphragm gets deflected. The movement of the diaphragm makes the link rod to operate the cam shaft and thereby to move the break shoes. When the break pedal is released, the brake valve is closed which releases the pressure in the brake chamber. When the brake shoe operating cam rotates in the reverse direction the brakes are released.

UNIT - V

Alternative Energy Sources

PART - A

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1. What is CNG?

CNG – compressed natural Gas as an alternate fuel for automotive usage would be of great use in reducing no fuel. Consumption as well as patterns of pollutants: This alternate fuel reduces considerably the dependence on conventional automotive fuels, thus achieves a saving in terms of foreign exchange as well as reduction in emission of toxic pollutants.

2. What is the general composition of natural Gas?

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane (CH₄)</td>
<td>85-90%</td>
</tr>
<tr>
<td>Ethane (C₂H₆)</td>
<td>5-7%</td>
</tr>
<tr>
<td>Propane (C₃H₈)</td>
<td>2%</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>3-5%</td>
</tr>
<tr>
<td>Others</td>
<td>1%</td>
</tr>
</tbody>
</table>

3. State some physical properties of Natural Gas?

1. Colour less.
2. Odour less.
4. Lighter than air.

4. What is the need for using CNG in automotives?

1. Rising urban pollution.
2. Rising Global concern for environment.
3. Rising vehicle pollution.
4. Rising public awareness and expectations.
5. Economics.

5. What are the constraints in CNG?
   1. Gas availability
   2. Capacity planning becomes difficult due to non-availability demand projections
   3. Availability of CNG equipment
   4. Pipeline network infrastructure
   5. Competition from other fuels.

6. State four advantages of using CNG over diesel?
   1. Natural gas (CNG) is higher than air and therefore dispersed quickly in the event of leakage instead of puddling line petrol and diesel.
   2. Natural Gas ignites at higher temperature (550-704°C) than petrol and diesel.
   3. The explosive limit of natural gas mixture is higher than air diesel mixture.
   4. Natural Gas provides clean burning characteristics.

7. What are the components of LPG?
   1. Vapourizer
   2. Regulator
   3. Safety valve
   4. Mixer
   5. Fuel line.

8. What are the advantages of using LPG in automotives?
   1. High octane number (110) compared to that of petrol (81). Hence is possible smooth combustion and knocking is eliminated.
   2. It blends with gas combustions mixture thus resisting in better combustion.
   3. there is absence of acid and carbon deposits, this ensures longer life.
4. causes less pollution.
5. LPG is a much cleaner and cheaper automotive fuel than gas line.
6. LPG has superior antiknock characteristics compared to gasoline and does not pre ignite early

9. What are the disadvantages of using LPG in automotives?

1. Hazardous to work with.
2. Decreases load carrying (capacity as the carrying load increases.
3. Reduces volumetric efficiency due to its heat of vaporization

10. What is the need for the Hydrogen Fuel?

Hydrogen is an excellent fuel, which could be the acceptable as permanent energy source that meets most of the obvious requirements for universal application in energy consumption in automobiles. To hydrogen is mainly produced by catalytic steam reforming of natural gas.

\[ \text{CH}_4 + \text{H}_2\text{O} \rightarrow \text{CO}_2 + 3\text{H}_2 \]

11. What is Electrolysis of water?

Water is made electrically conducting, by adding small amount of sulphuric acid (H\(_2\) SO\(_4\)) (or) Pottasium Hydroxide (KOLL). Electric current is passed between the electrodes leading to the separation and collection of H\(_2\) and O\(_2\) Separately. The energy efficiency of this process is about 75%.

12. How can you get a hydrogen from thermal decomposition of water?

Water can be split by the application of heat as,

\[ 2\text{H}_2\text{O} \rightarrow 2\text{H}_2 + \text{O}_2 \]
13. State any four properties of hydrogen?

1. Hydrogen has a very low density both as gas and as liquid. Hence inspite of its high calorific value on mass basis, its energy density as a liquid is only one fourth of that of gasoline.
2. Hydrogen has to stored as compressed gas, as liquid or in absorbed form (hydrides) none of which is convenient as gasoline storage.
3. Hydrogen has a high self ignition temperature, but requires very little energy to ignite it.
4. An important point to be noted that is no wide ignition limits of hydrogen. Only 4% by volume of hydrogen in hydrogen air mixture and 75% by volume of hydrogen in hydrogen air mixture are both ignited.

14. What are the advantages of hydrogen fuel?

1. It is extremely clean burning. The main product of combustion is only water.
2. It can be produced from an abundant raw material, water and hence is renewable
3. Many of its properties are highly sited to I.C. engines.

15. What are the disadvantages of hydrogen fuel?

1. Its energy density, either as a gas or as a liquid is quite low.
2. Since it is a highly reactive fuel, special safety precautions are necessary in handling it.
3. It can produce pre ignition and back flash in engines, again due to its high reactivity.

16. What are the basic components in electric vehicle?

1. Motor
2. Power pack
3. on beard charger
4. Motor controller
5. Energy management system
6. Regenerative braking.

17. State any four advantages of electric car?

1. Construction is very simple as more are less number of working parts.
2. Vibration free operation.
3. Starting of car is easy.
4. Need of gear boxes are avoided.

18. State any four disadvantages of electric car?

1. Batteries life is shot, hence high replacement costs.
2. As the batteries are to be recharged, the range is limited about 60-tonn
3. Need for the distribution of charging points.
4. More energy will be needed in are night to charge the batteries.

19. What are the types of hybrid system?

1. Parallel hybrid system.
2. series hybrid system

20. What are the advantages of hybrid system?

1. Exceptionally low emission levels
2. The cost of the engine is low as compared to that of installation of gas turbine and motor etc.
3. Lessees fuel consumption.

21. What are the disadvantages of Hybrid system?
22. What is fuel cell?

A fuel cell is a device that harnesses the energy produced during the electro chemical reaction between hydrogen and oxygen. The products are water heat and electricity. There are no oxides of nitrogen, HC and carbon monoxide.

23. What are the needs for using fuel cells in automobile?

1. Depletion of conventional types of fuels leading to energy crisis.
2. How emission required to make a car economic friendly.
3. To attain certain standards of emission control.

24. State any four advantages of fuel cells?

1. The fuel cell have very low emission of pollutants.
2. The oxygen air bas are very useful for the passengers.
3. The fuel cell prevents the depletion of the fossil fuel.
4. more efficient than IC engines.

25. State what are the disadvantages of fuel cell?

1. Increased load capacity.
2. An evaporate storage methods for hydrogen have to be used.
3. Costly construction.
PART – B

1) Describe the principle of working of a fuel cell with reference to H₂ – O₂ cell.

As stated these are electro-chemical devices in which the chemical energy of fuel is converted directly into electric energy. The chemical energy is the free energy of the reactants used. This conversion takes place at constant temperature and pressure. The basic feature of the fuel cell is that the fuel and its oxidant are combined in the form of ions rather than neutral molecules.

The first practical fuel cell was demonstrated by Francies T. Bacin and J.C. Frost of Cambridge University in 1959. As per the fuel used the main types of fuel cells are:

a) Hydrogen (H2) fuel cell,
b) Hydrazine (N2H4) fuel cell,
c) Hydrocarbon fuel cell, and
d) Alcohol (Methanol) fuel cell.
The operation of the fuel cell can best be described with reference to a specific device. Fuel cell can be adapted to a variety of fuels by changing the catalyst. Here Hydrogen, Oxygen (Hydrox) cell is described for example. These types are the most efficient and the most highly developed.

The main components of a fuel cell are:

- a) a fuel electrode (anode),
- b) an oxidant or air electrode (cathode), and
- c) an electrolyte

In most fuel cells, hydrogen (pure or impure) is the active material at the negative electrode and oxygen (form the oxygen or air) is active at the positive electrode. Since hydrogen and oxygen are gases; a fuel cell requires a solid electrical conductor to serve as a current collector and to provide a terminal at each electrode. The solid electrode material is generally porous.

Porous nickel electrodes and porous carbon electrodes are generally used in fuel cells for commercial applications. Platinum and other precious metals are being used in certain fuel cells which have potential utility in military and space applications. The porous electrode has a larger number of sites, where the gas, electrolyte and electrode are in contact; the electro chemical reactions occur at these sites. The reactions are normally very slow, and catalyst is included in the electrode to expedite them. The best electro chemical catalysts are finely divided platinum or platinum-like metal deposited on or incorporated with the porous electrode material. Since the platinum metals
are expensive, other catalysts, such as nickel (for hydrogen) and silver (for oxygen), are used where possible. The very small catalyst practices provide a large number of active sites at which the electro-chemical reactions can take place at a fairly rapid rate.

Although practical fuel cells differ in design details, the essential principles are the same, as indicated by the schematic illustration in figure. Hydrogen gas is supplied to one electrode and oxygen gas (or air) to the other. Between the electrodes is a layer of electrolyte. Most existing fuel cells operate at temperature below about 200°C; the electrolyte is then usually and aqueous solution of an alkali or acid. The liquid electrolyte is generally retained in a porous membrane; but it may be free flowing in some cells. Different electric current is drawn from the cell in the usual manner by connecting a load between the electrode terminals.

The electrochemical reactions occurring at the electrodes of a hydrogen-oxygen cell may vary with the nature of the electrolyte, but basically they are as follows. At the negative electrode, hydrogen gas (H2) is converted into hydrogen ions (H*) i.e. hydrogen with a positive electric change, plus an equivalent number of electrons; thus

\[
H_2 \rightarrow 2H^* + 2e
\]

At this electrode, hydrogen is diffused through the permeable nickel in which is embedded a catalyst. The catalyst enables the hydrogen molecules, H2 to be absorbed, on the electrode surface as hydrogen atoms, which react with the hydroxyl ions (OH) in the electrolyte to form water.

When the cell is operating and producing current, the electrons flow through the external load to the positive electrode; here they interact with oxygen (O2) and water (H2O) from the electrolyte to form negatively charged hydroxyl (OH) ions, thus

\[
1/2 O_2 + H_2O + 2e \rightarrow 2OH
\]

The hydrogen and hydroxyl ions then combine in the electrolyte to produce water

\[
H^* + OH \rightarrow H_2O
\]

The Electrolyte is typically 40% KOH solution because of its high electrical conductivity and it is less corrosive than acids.

The above equations show that hydroxyl ions produced at one electrode are involved in the reaction at the other. Also electrons are absorbed from the oxygen electrode and released to the hydrogen electrode. Addition of the three forgoing reactions show that when the cell is operating, the overall process is the chemical combination of hydrogen and oxygen (gasses) to form water that is
\text{H}_2 + \frac{1}{2} \text{O}_2 \rightarrow \text{H}_2\text{O}

The oxygen and hydrogen are converted to water, which is the waste product of the cell. The reactants are stored outside the cell (note difference from storage battery) and the electrodes and electrolyte are not consumed in the overall process. These properties lead to the design of convenient small size and long life power units.

2) What are the advantages and disadvantages of a fuel cell?

**Advantages:**

a) It has very high conversion efficiencies as high as 70 percent have been observed, since it is a direct conversion process and does not involve a thermal process. In the conventional thermal process for generating electricity, heat energy produced by combustion of the fuel is converted partially into mechanical energy in a steam turbine and then into electricity by means of a generator. The efficiency of a heat engine is limited by the operating temperatures, and in the large fuel is converted into electrical energy. Fuel cells, on the other hand, are not heat engines and are not subjected to their temperature limitations.

b) Fuel cells can be installed near the use point, thus reducing electrical transmission requirements and accompanying losses. Consequently considerably higher efficiencies are possible.

c) They have few mechanical components; hence, they operate fairly quietly and require little attention and less maintenance.

d) Atmospheric pollution is small if the primary energy source is hydrogen, the only waste product is water; if the source is a hydrocarbon, carbon dioxide is also produced. Nitrogen oxides, such as accompany combustion of fossil fuels in the air, are not formed in the fuel cell. Some heat is generated by a fuel cell, but it can be dissipated to the atmosphere or possibly used locally.

e) There is no requirement for large volumes of cooling water such as are necessary to condense exhaust system form a turbine in conventional power plant.

f) As fuel cells do not make noise, they can be readily accepted in residential areas.

g) The fuel cell takes little time to go into operation.
h) The space requirement for fuel cell power plant is considerably less as compared to conventional power plants.

**Disadvantages:**

The main disadvantages of fuel cells are their high initial cost and low service life.

3) **Write down the properties of Hydrogen?**

Hydrogen at ordinary temperature and pressure in a light gas with a density only 1/14\(^{th}\) that of air and 1/9\(^{th}\) that of natural gas under the same conditions. By cooling to the extremely low temperature of 253°C at atmospheric pressure, the gas is condensed to a liquid with a specific gravity of 0.07, roughly 1/10\(^{th}\) that of gasoline.

The standard heating value of hydrogen gas is 12.1 MJ/cu m compared with an average of 38.3 MJ/cu m for natural gas. The heating value of liquid hydrogen is 120 MJ/kg or 8400 MJ/cu m; the corresponding value of liquid hydrogen is 120 MJ/kg or 8400 MJ/cu m; the corresponding value of gasoline (or approximately for jet fuel) is 44 MJ/kg or 32,000 MJ/cu m. Hence for, producing a specific amount of energy, liquid hydrogen is superior to gasoline (or jet fuel) on a weight basis but inferior on a volume basis.

The flame speed of hydrogen burning in air is much greater than for natural gas, and the energy required to initiate combustion (i.e. the ignition energy) is less. One consequence of the low ignition energy is that flameless combustion on a catalytic (finely divided metal) surface is possible with hydrogen at much lower temperature than flame burning.

Mixture of hydrogen and air are combustible over an exceptionally wide range of composition; thus, the flammability limits at ordinary temperatures extend form 4 to 74 percent by volume of hydrogen in air. (Detonation can occur between 18 and 59 percent). This wide range has an important bearing on the use of hydrogen fuel in internal combustion engines. The engine will operate, although not necessarily with the same efficiency, from very rich (excess fuel) to very lean (excess air) mixtures. The adjustment of air-to-fuel ratio is thus much less critical than in a gasoline engine.

4) **What are the different methods for hydrogen production? Explain electrolysis or the electrolytic production of hydrogen.**

The methods of producing hydrogen may be classified according to the immediate source of addition of energy to decompose, thus electrical energy (in electrolysis), heat energy (in thermo chemical methods), fossil fuels, and solar energy.

**Electrolysis or the electrolytic production of Hydrogen:**
The process of splitting water into hydrogen and oxygen by means of a direct electric current is known as electrolysis; this is the simplest method of hydrogen production. In principle, an electrolysis cell consists of two electrodes, commonly flat metal or carbon plates immersed in an aqueous conducting solutions called the electrolyte. A source of direct current voltage is connected to the electrodes so that an electric current flows through the electrolyte from the positive electrode (or anode) to the negative electrode (or cathode). As a result, the water in the electrolyte solution is decomposed into hydrogen gas (H₂) which is released at the cathode, and oxygen gas (O₂); released at the anode. Although only the water is split, an electrolyte (e.g. KOH solutions) is required because water itself is a very poor conductor of electricity.

![Simple electrolytic cell diagram](https://ourmechanicalengg.wordpress.com/)

Ideally, a voltage of 1.23 volts should be sufficient for the electrolysis of water at normal temperature and pressure. For various reasons, especially the slowness of the electrode processes that lead to the liberation of hydrogen and oxygen gases, higher voltages are required to decompose water. The decomposition voltage increase with the current density (i.e. the current per unit area of electrode). Since the rate of hydrogen production is proportional to the current strength a high operating current density is necessary for economic reasons. Hence, in practices the decomposition voltage (per cell) is usually around 2 volts.
Theoretically, 2.8 kW-hr of electrical energy should produce one cu.m. of hydrogen gas. Because of the higher than ideal decomposition voltage, however the actual electrical energy requirement is generally form 3.9 to 4.6 kw-hr per cu.m.) This means that the efficiency of electrolysis (i.e. the proportion of the energy supplied that is used in electrolysis) is roughly 60 to 70%.

The electrolysis efficiency can be increased by decreasing the decomposition voltage for a given current density. To achieve this, the electrode surface must be able to catalyze (i.e. expedite) the electrode processes. One of the best catalysts is platinum in a finely divided form, deposited on a metal base. However, because of the high cost of platinum, other electrode surface materials are used commercially. For practical water electrolysis, the electrodes are generally of nickel-plated steel. The effective electrode surface area (and hence the rate of the electrode process) is increased by depositing porous nickel on a wire gauge, or a highly corrugated steel base. Research is being directed at the development of improved electrodes that will give better electrolysis efficiency at a reasonable cost.

Diaphragms prevent electronic contact between adjacent electrodes and passage of dissolved gas or gas bubble; from one electrode compartment to another (leading to a decrease in current efficiency and possible to explosions), without themselves offering an appreciable resistance to the passage of current within the electrolyte. Dissolved-gas crossover is serious only in pressure operations; to prevent the passage of gas bubbles, the diaphragm must consist of small pores whose capillary pressure is greater than the maximum differential pressure applied across the cell.

Asbestos is the most common material for cell diaphragms. At atmospheric pressure, woven asbestos cloth is used, sometimes with fine nickel wire to support the structure. Pressure electrolyzes usually have a mat made of woven or felted asbestos fibers that produces a fine pore structure, giving a higher resistance to the generation of gases. This mat is sometimes supported by the electrodes.

Three major factors determine the usefulness of an electrochemical cell for hydrogen production. One is the energy efficiency, related to the cell’s operating voltage: another is the capital cost of the plant, related to the rate of hydrogen production from a cell of a given size. These two factors are closely inter-related. The third factor is the life time of the cell and its maintenance requirements, which involve the materials used in its construction and the operating conditions selected.

5) Describe the more popular method of hydrogen production?

In ordinary electrolysis, water is decomposed into hydrogen and oxygen by passing an electric current, from an outside source, between two electrodes in an electrolyte solution. In photo electrolysis, a current is generated by exposing on or both electrodes to sunlight. Hydrogen and oxygen gases are liberated at the respective electrodes by the decomposition of water, just as an ordinary
electrolysis. At least one of the electrodes in photo electrolysis is usually a semiconductor; a catalyst may be included to facilitate the electrode process. In the cells studied so far, the efficiency for the conversion of solar energy into hydrogen-oxygen energy has been very low. Research is being directed at increasing this efficiency by selection of electrode materials, electrolyte solutions, and electrode catalysts.

Electrolysis is a more attractive way of producing hydrogen with solar radiation since it can be operated intermittently and therefore needs no storage.

The solar electricity needed for electrolysis can be produced either photo electrically or thermo chemically. Both technologies are available today. Solar electrolytic hydrogen production is therefore a question of the cost of component and of development. Solar thermal power plant (Tower concept Figure) is an example of a solar electricity generation station. When the breakthrough in high temperature electrolysis comes it could lead to an interesting application for thermo mechanical solar electricity generation: only part of
the coolant heated in the receiver is released into the turbo generator; the remainder is used to supply the heat to electrolyser. Saving can be made with such hybrid electrolysis systems.

6) Write short notes on applications of fuel cells used in automotive vehicles?

The applications of fuel cell may be discussed with reference to the following:

   a) Domestic use
   b) Central power stations
   c) Automotive vehicles
   d) Special applications

   The e.m.f. or voltage of a fuel cell depends to some extent on the discharge current strength. The average voltage per cell is 0.75 volt. By joining a number of cells in series and parallel can provide any reasonable voltage and current. Fuel cells generate direct current which can be used for electric lamps and some small applications such as heat pumps, motors etc. conversions into alternating current by means of an inverter might be necessary.

   Fuel cell can be made in modules of different size that are readily transportable. They can then be assembled at any location to provide a specified voltage and power output. The modular design should make it possible to construct plants of various capacities for different requirements.

   If fuel cells of reasonably low cost and long life can be produced, a major use might be by electric utilities for load leveling as explained below. A long term possibility is a central-station power plant in which coal is gasified and the gas is used to generate electricity directly by means of fuel cells. Such an installation is expected to have a higher efficiency for fuel utilization than a conventional steam-electric plant.

   Portable generating sets seem to be a favorable field for fuel cells. Here, already, fuel cells appear to be competitive as compared with conventional source. Low temperature fuel cells have a favorable position for operating times of 3,000 to 4,000 hours per year, using methanol as a fuel.
Large generating stations operate most efficiently at a steady (rated) power output, but the demand for power is variable. When the demand or load is less than the rated output, the excess would be used to generate hydrogen by electrolysis of water. At times when the load is greater than the power supply, the hydrogen would be used in fuel cells to satisfy the additional demand. By siting fuel cells near load centers where the demand exists, electrical transmission and distribution costs would be reduced, although there would be some cost for transporting the hydrogen. Sometimes new load centers are formed as a result of housing and industrial developments. To satisfy the power demand utilities, will either build additional large plants, which require considerable capital expenditures, or utilized diesel engines of gas turbines operated by natural gas or a petroleum fuel. The same fuel might be utilized more economically in fuel cells located near the new load center.

Fuel sources have been proposed for remote or rural areas or unattended locations, for mobile and emergency power sources, and for vehicle propulsion. The high temperature batteries may be the best candidates for vehicle propulsion in the long term, but certain fuel cells are potential alternatives to storage batteries for electric vehicles. Such vehicles may have longer travel ranges than those with the most advanced storage batteries. The fuel cells of special interests are the aluminum-air, methanol-air, and the hydrogen-oxygen cell. The aluminum-air cell is of special interest for electric vehicle propulsion because of the high specific energy that is possible. An aluminum-air battery and associated equipment may weight roughly the same as the gasoline engine and fuel in a medium size automobile. A five passenger electric vehicle is expected to have a travel range of atleast 1600 km before replacement of the aluminum electrodes is necessary. However, the aluminum hydroxide produced when the cell operates. It must be removed every 400 to 600 km, and water must be added at similar intervals.

The range of a vehicle with a methanol-air battery depends on the volume of the fuel tank, that is, on the quantity of methanol that can be carried. If fairly pure hydrogen gas were available at a reasonable price, the hydrogen-oxygen (air) fuel cell might be used for electric vehicle propulsion. The major problem would be storage of the fuel on the vehicle. However, the high efficiency of the fuel cell would compensate for the weight of the hydrogen storage system.

Many of the fuel cells currently under development are for special applications where convenience is of paramount importance, cost is secondary. For these applications hydrogen is the superior fuel from the view point of reactivity and availability of invariant electrolyte, although it is relatively costly. It seems likely that hydrogen-oxygen and hydro carbon-oxygen cells will be used to an increasing extent in special military and space projects.

7) Write a brief note on hydrogen transportation?

Pipe lines:
At present, the long distant pipelining of hydrogen is an operation that is carried out by only a few specialized companies in different parts of the world. It is of interest to compare the design requirements of a pipeline for hydrogen with those of a pipeline for natural gas. Heating value of hydrogen in only 12.1 MJ/cu m, as compared to about 38.3 MJ/cu m for natural gas. This implies that to deliver the same quantity of energy, three times the volumes for hydrogen must be transmitted. On closer inspection, however, one finds that the capacity of pipeline depends upon the square root of the density of the gas, and because the density of hydrogen is about one ninth \((1/9)\) that of natural gas, there is a compensating factor of the one third that results in the given pipe having essentially the same energy carrying capacity for natural gas as for hydrogen. This is true at atmospheric pressure. As the pressure increases to typical pipeline operating pressure of 50 kg/cm² (2 MPa) or so, the compressibility factor for hydrogen is somewhat different that for natural gas, and this results in a slightly unfavorable carrying capacity for natural gas, and this results in a slightly unfavorable carrying capacity for hydrogen. At 50 kg/cm² (5 MPa), the ratio of heating values for a given compressed volume of hydrogen and natural gas has changed from 3:1 to 3:83:1. Long distances gas transmission lines of lengths greater than about 90 km must be supplied with pipeline compressors at fairly regular intervals. Hydrogen compressor must handle a considerably greater volume of the gas-somewhere between there to four times the number of cu m for the same energy capacity. Secondly, the horse power required to drive a hydrogen compressor is considerably greater than that needed to drive a natural gas compressor for the same gas energy throughput. Thirdly, the design of rotary compressors commonly used for natural gas lines appears to be inadequate for hydrogen operations.

It is possible to estimate the cost of transmitting hydrogen by pipeline from knowledge of the required pipeline diameter, compressor capacity and horse power, and energy throughput required. In the case of design of a pipeline of hydrogen transmission the cost of fuels used to drive the engines for compressors is also a highly deciding factor, because the compression energy is so much higher than that of natural gas.

One of the principal concerns about hydrogen transmission is the fear of hydrogen embitterment of the pipeline materials. A number of metal lose their mechanical strength of exposure of hydrogen; the phenomenon called hydrogen embattlement, is specially significant for steel in hydrogen under pressure. Operating experience with common pipeline steels at pressures upto about 35 kg/cm² (3.5 MPa). However the behavior at higher pressure is uncertain, and more experimental work needs to be carried out to get some definite data.

**Liquid Hydrogen Transportation:**
Hydrogen in bulk can be transported and distributed as the liquid. Double-walled, insulated tanks of liquid hydrogen with capacities of 7000 gal (26.5 cu m) or more are carried by road vehicles and up to 34,000 gal (129 cu m) by railroad cars. Distribution of liquid hydrogen by pipelines, jacketed with liquid nitrogen, has been proposed. The costs would be justifiable for certain fuel applications where the liquid is required.

**Metal Hydride Transportation:**

Hydrogen can also be transported as a solid metal hydride. The main drawback, as stated earlier, is the weight of the hydride relative to its hydrogen content.

8) **Write the main applications of hydrogen gas?**

**Utilization of Hydrogen Gas:**

Hydrogen gas can be utilized:

- a) For residential uses
- b) For industrial uses
- c) For an alternative transport fuel
- d) For as an alternative fuel for aircraft
- e) For electric power generation (Utilities)

**Residential uses:**

Electricity for lighting and for operating domestic applications (e.g. refrigerators) could be generated by means of fuel cells, with hydrogen gas at one electrode and air at the other.

**Road vehicles:**
The use of hydrogen fuel in internal combustion engine for automobiles, buses, trucks, and farm machinery has attracted interest as a means of conserving petroleum products and of reducing atmospheric pollution. Because of the fuel is a gas, the conventional carburetor of a spark-ignition engine, in which liquid gasoline is vaporized in air, must be modified for use with hydrogen. The method of using hydrogen as a fuel in CI engines are as follows:

a) A mixture of fuel gas and air, with an approximately constant fuel to air ratio, is introduced into the cylinder intake manifold. The engine power (i.e. vehicle speed) is controlled by varying the quantity of mixture entering the cylinder by means of a throttle value. (The same procedure were used in the otto and other early I.C. engines with coal gas the fuel). Stable operation, especially at higher speeds, may require addition of water vapor to the fuel-air mixture; this can be achieved by returning part of the exhaust gas to the manifold.

b) The hydrogen gas under pressure in injected through a value directly into the engine cylinder, and the air is admitted through another intake valve. Since the hydrogen and air are supplied separately, an explosive mixture does not occur except in the cylinder. This scheme is considered to be safer than the previous one, in which such a mixture is formed in the manifold. The engine power output is controlled by varying the pressure of hydrogen gas from about 14 atm at low power to 70 atm at high power. The hydrogen is required to be stored as a compressed gas.

c) The hydrogen gas at normal or moderate pressure is drawn through a throttle value into the engine cylinder during the intake stroke. At the same time, unthrottled air is drawn in through the intake port. Here, also, there is no explosive mixture except in the cylinders. The engine power is varied by adjusting the hydrogen inlet throttle. Since the air supply is unthrottled, there is a change in the proportion of fuel in the cylinder and consequently a change in the power developed. This scheme of power variation is possible because of the wide composition range over which hydrogen-air-mixture can be ignited.

Another modification arises form the high speed of the hydrogen flame in air; this require that the ignition time be retarded (i.e. less spark advance) compared with a gasoline engine.

9) Compare hydrogen fuel with various alternative fuels?

Hydrogen as an alternative fuel for motor vehicles:

The consequences of using hydrogen in motor vehicles are best seen by comparing it with other chemical energy vectors. Table 1 shows the require tank volume and weight of fuel for typical non-conventional fuels compared with iso-octane, which is typical of the various hydrocarbons that constitute gasoline. Comparison of iso-octane with methane (liquid natural gas), methanol and hydrogen
**Table 1** comparison of various alternative fuels and storage

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Storage capacity Wt. %</th>
<th>Density of Hydrogen g/l</th>
<th>Energy density K Wh/kg</th>
<th>Energy density k/Wh/l</th>
<th>Operating temperature at (2 bar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium hydride</td>
<td>7</td>
<td>101</td>
<td>2.33</td>
<td>3.36</td>
<td>350°C</td>
</tr>
<tr>
<td>Magnesium nickel hydride</td>
<td>3.16</td>
<td>81</td>
<td>1.05</td>
<td>2.69</td>
<td>250°C</td>
</tr>
<tr>
<td>Iron titanium hydride</td>
<td>1.75</td>
<td>96</td>
<td>0.58</td>
<td>3.18</td>
<td>-10°C</td>
</tr>
<tr>
<td>Liquid hydrogen</td>
<td>100</td>
<td>71</td>
<td>33.3</td>
<td>2.36</td>
<td>-250°C</td>
</tr>
<tr>
<td>Methanol</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid methane</td>
<td>13.8</td>
<td>5.8</td>
<td></td>
<td></td>
<td>-161°C</td>
</tr>
<tr>
<td>Ammonia</td>
<td>5.14</td>
<td>4.21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrazine</td>
<td>4.6</td>
<td>4.65</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iso-octane</td>
<td>12.7</td>
<td>8.76</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(It is taken here as representative of gasoline, which is a mixture of low boiling hydrocarbons)
Table 2 Weight required for the storage of fuels

<table>
<thead>
<tr>
<th></th>
<th>Hydrogen (kg)</th>
<th>Hydride (kg)</th>
<th>Storage container, etc. (kg)</th>
<th>Total weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium hydride</td>
<td>8.5</td>
<td>121</td>
<td></td>
<td>193</td>
</tr>
<tr>
<td>Magnesium nickel hydride</td>
<td>8.5</td>
<td>269</td>
<td></td>
<td>430</td>
</tr>
<tr>
<td>Iron titanium hydride</td>
<td>8.5</td>
<td>485</td>
<td></td>
<td>775</td>
</tr>
<tr>
<td>Liquid hydrogen</td>
<td>8.5</td>
<td>-</td>
<td>50</td>
<td>58.5</td>
</tr>
<tr>
<td>Equivalent quantity of gasoline</td>
<td>22.3</td>
<td>-</td>
<td>15</td>
<td>37</td>
</tr>
<tr>
<td>Equivalent quantity of methanol</td>
<td>50.5</td>
<td>-</td>
<td>20</td>
<td>70</td>
</tr>
</tbody>
</table>