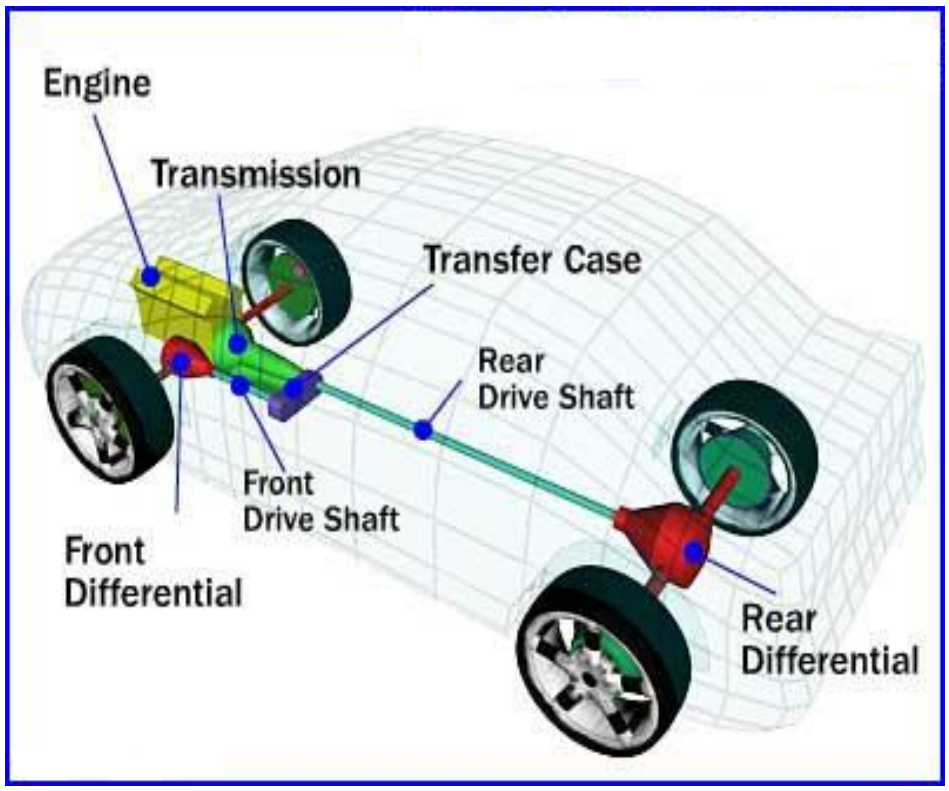
DHANALAKSHIMI SRINIVASAN
COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

ME8091 - AUTOMOBILE ENGINEERING

PART A: 2 MARKS

PART B: 16 MARKS



ME6602 - AUTOMOBILE ENGINEERING

PART A
UNIT-1
VEHICLE STRUCTURE AND ENGINES

1. What are the functions of a frame? (Dec'13, May'07, Dec 09)

- To support the chassis components and the body.
- To withstand static and dynamic loads without undue deflection or distortion.
- To carry the load of the passengers or goods carried in the body.

2. What loads are coming to axle? (May '06, 09, Dec 14)

Vertical bending load due to vehicle weight

- Driving torque
- Braking torque
- **Side thrust**

3. Name the different kind of resistances to vehicle motion. (Jun'07,Dec' 11)

- Air resistance
- Rolling resistance
- Gradient resistance

4. Why is the frame narrow at front? (Dec'11, May'12)

The frame is narrowed at the front to provide a better steering lock. This also permits smaller turning circle radius

5. What are the stresses to which the frame members are subjected to? (Dec'13, May'10)

- Frame longitudinal members – bending stress
- Frame side members – twisting stress

6. Name few components of engine. (Dec'05, May'06, Dec '09,'13)

1. Cylinder block
2. Cylinder head
3. Crankcase
4. Cylinder
5. Piston
6. Connecting rod
7. Crankshaft
8. Camshaft Valves Spark plug (in the case of petrol engine)
9. Fuel injector (in the case of diesel engine)

7. What are the types of frames? (Dec'13, May'11, Dec 09)

- Ladder type frame
- Perimeter type frame
- X type frame
- Backbone type frame

8. What is meant by the term Chassis? (Dec'12, May'10, Dec 09)

A complete vehicle without a body structure is known as Chassis. It comprises of basic structure, power unit, transmission system, controls and auxiliaries.

9. What are the two types of cylinder liners? (Dec'14, May'11, Dec 09)

- Dry liners
- Wet liners

10. What are the functions of piston rings? Types? (Dec'14, May'12, Dec 08)

To provide a gas tight seal between the piston and cylinder liner to prevent the escape of gases from top side of the piston to the underside.

- Compression rings
- Oil rings

UNIT-2
ENGINE AUXILIARY SYSTEMS

1. **What is Gasoline Direct Injection? (Dec'05, May'06, Dec '09,'13)**

The gasoline (petrol) is directly into the cylinder at the end of compression stroke as such in diesel engines. This is called Gasoline Direct Injection (GDI)

2. **Define common rail Direct injection system. (Dec'13, May'07, Dec 09)**

A common rail which is maintaining high fuel pressure is connected to individual fuel injectors of a multi cylinder engine.

3. **What is an Electronic ignition system? (Dec'13, May'10)**

The ignition system, in which the mechanical contact points are replaced by electronic triggering and switching devices, is known as electronic ignition system.

4. **What are the functions of Turbo chargers? (Dec'14, May'11, Dec 09)**

To produce more power from the same size engine
To provide the altitude compensation
To improve more complete combustion & hence less emissions

5. **What are the advantages of petrol injection? (May '06, 09, Dec 14)**

High power can be developed
It has quick starting characteristics
It has lowest specific fuel consumption
Less engine emissions than carbureted engines

6. **What is super charging? (Dec'14, May'12, Dec 08)**

The process of increasing the density of inducted charge/ air is known as supercharging. It is performed for the following reasons.

- To produce more power from the same size engine
- To provide the altitude compensation
- To improve more complete combustion & hence less emissions

7. **What is meant by carburetion in I.C engine? (Dec'13, May'08, Dec'11)**

The method of preparing the air-fuel mixture in an IC engine is known as carburetion. The device used for this purpose is known as carburetor.

8. **What are the advantages of electronic fuel injection system over conventional injection?**

- Cold starting is easier
- High fuel economy
- Less engine emissions

Quick response to varying engine operating conditions

9. **What are the functions of generator and starting motor? (Dec'13, May'10)**

The function of the generator is to produce electricity to charge the battery. The starting motor is used to crank the engine during the starting condition.

10. **What is the function of an ignition system in I.C engine? (Dec'13, May'11, Dec 09)**

The function of an ignition system is to ignite the air-fuel mixture at the end of the compression stroke.

11. What are the chemicals used in battery?

PbO_2 – Positive plate
Pb – Negative plate
Electrolyte – Diluted Sulphuric acid

UNIT-3
TRANSMISSION SYSTEMS

1. What is the function of clutch? (May '06, 09, Dec 14)

The function of the clutch is to connect and disconnect the engine with road wheels. The clutch has to be disengaged during gear shifting, idling etc.

2. What are the types of clutch? (Dec'13, May'11, Dec 09)

- Friction clutches
- Single plate clutch
- Multi plate clutch
- Cone clutch
- Semi centrifugal clutch
- Centrifugal clutch Fluid clutches
- Fluid flywheel

3. State the requirements of an automotive clutch. (Dec'11, May'12)

- Torque transmission should be maximum
- Gradual engagement of clutch plates
- Heat dissipation should be more
- Dynamic balancing of clutch components
- Vibration damping.

4. Why is gear box necessary in automobile? (Dec'14, Dec 08)

- The variation of resistance to vehicle motion at different speeds
- The variation of tractive effort of the vehicle required at various speeds

For above said reasons, a gearbox is necessary in an automobile

5. What is tractive effort? (May'12, Dec 09)

It is the force available at the road wheels for propelling the vehicle.

$T = \mu W$

Where, T = Tractive effort

μ– Coefficient of friction between tyre and road surface

W – Load of the vehicle

6. What is an over drive? (May'12, Dec 10)

When the speed of the output shaft is greater than the speed of the input shaft, then the drive is known as overdrive. Example: 0.8:1 or 0.9: 1

7. What is a universal joint? What are its types? (May'10, Dec 08)

Universal joint is a type of flexible joint between two shafts who axes intersect and may assume different inclinations at different times. It is used to transmit power even at inclined angles of the shaft.

Types

- Yoke joint
- Single cardan joint
- Double cardan joint
- Rag joint
- Canfield joint

8. State the functions of a slip joint. (Dec'14, Dec 08)

The function of a slip joint is to accommodate the propeller shaft length variations, when a vehicle is moving over a bump or bit.

9. What is Hotchkiss drive and Torque Tube drive? (Dec'13, May'08, Dec 08)

In Hotchkiss drive, the loads such as vehicle weight, driving torque, braking torque and side thrust all are taken by leaf springs. Two universal joints and one slip joint are must needed.

In Torque tube drive, the driving torque and braking torque are taken by torque tube while the vehicle weight and side thrust are taken care of by leaf springs. One universal joint is just sufficient.

10. What is the function of differential unit? (Dec'14, May'12, Dec 08)

The function of a differential unit is to permit the vehicle turns without wheel skidding. It permits higher speed for outer wheels and reduced speed for inner wheels during turning.

11. What is meant by differential lock? (Dec'07, May'14, Dec 08)

A Differential lock will transmit the same amount of power to both wheels on the axle - which is very useful in 4WD applications where a truck might be stuck and have problems getting out of deep mud or snow.

UNIT- 4
STEERING, BRAKES AND SUSPENSION SYSTEMS

1. Define wheel track and wheel base. (Dec'14, May'12, Dec 08)

The distance between the tyre centers, mounted on the same axle is known as wheel track. The wheelbase is the distance between the centers of the front and rear wheels

2. Give a brief note on damper. (Dec'14, May'12, Dec 08)

It is used to dampen the vibrations of the suspension springs. It is mostly used in independent suspension.

3. Distinguish between disc brake with drum brake. (Dec'14, May'12, Dec 08)

Sl.No	Drum Brakes	Disc Brakes
1	Relatively cheaper	Costlier
2	More weight	Lighter than drum brakes
3	Easily subjected to brake fading	Offer resistance to brake fading
4	Non uniform pressure distribution	Uniform pressure distribution

4. Define steering gear. (Dec'14, May'12, Dec 08)

The steering gear is used to convert the rotational movement of the steering wheel into linear movement of the steering linkage. Moreover it provides mechanical advantage.

5. What is the purpose of Toe-in and Toe-out? (Dec'14, May'12, Dec 08)

The purpose of providing a toe in and toe out is straight line stability of the vehicle, after negotiating a turn.

6. What are the different types of tyres used in automobile? (Dec'14, May'12, Dec 08)

- Cross ply tyres
- Radial ply tyres
- Belted bias tyres

7. What are the different types of springs used in suspension system? (Dec'14, May'12, Dec 08)

- Leaf springs (Rigid axle suspension)
- Coil springs (Independent suspension)
- Torsion bar (Independent suspension)

8. Define king pin inclination. (Dec'14, May'12, Dec 08)

The tilt of the king pin from the vertical reference line is known as King Pin Inclination (KPI). It is also called as Steering Axis Inclination (SAI)

9. Give the function of tyre? (Dec'14, May'12, Dec 08)

- Supporting Vehicle Weight
- Transferring Traction & Braking forces to the Road Surface
- Changing & Maintenance Direction of Travel
- Absorbing Road shocks

10. Define castor and camber. (Dec'14, May'10, Dec 07)

Castor: The tilt of the king pin from the vertical reference line when viewed from side is known as castor.

Camber: The camber angle is the inward or outward tilt of the wheel relative to the vertical reference

UNIT- 5
ALTERNATIVE ENERGY SOURCES

1. **List the advantages of hydrogen fuel used in automobiles. (Dec'14, May'10, Dec 07)**
   It can be manufactured from water through electrolysis process
   It does not contain carbon. Hence, CO and unburned HC emissions are not present
   The flame speed is highest. Hence it results in high thermal efficiency
   It has wide ignition limits.

2. **What is a hybrid vehicle? (Dec'11, May'10)**
   A hybrid vehicle is a vehicle that uses two or more distinct power sources to move the vehicle. The term most commonly refers to hybrid electric vehicles (HEVs), which combine an internal combustion engine and one or more electric motors.

3. **What is a fuel cell? (Dec'12, May'11)**
   A fuel cell is an electrochemical device that converts a source fuel into an electrical current and water. It generates electricity inside a cell through reactions between a fuel and an oxidant, triggered in the presence of an electrolyte.

4. **Write the composition of LPG and CNG. (May'12, Dec 05)**
   Composition of CNG
   CH_4 = 70.9%, C 2H 6 = 5.10%, H 2 = 3%, CO + CO 2 = 22%
   Composition of LPG:
   Propane= 30 % and Butane = 70 %

5. **Define detonation and pre-ignition. (May'10, Dec 06)**
   The abnormal combustion occurring in IC engines is called as detonation. This results in sudden rate of pressure rise, abnormal heat release, heavy vibrations of the engine and loud noise operation.
   The ignition of the air-fuel mixture before the introduction of the spark in the combustion chamber is called as pre-ignition.

6. **What are the advantages of an electric car? . (Dec'07, May 08)**
   No emissions from an electric car
   It does not depend upon the availability fossil fuels

7. **State the advantages of fuel cell. (Dec'12, May'10)**
   - Higher efficiency than diesel or gas engines.
   - Quiet operation.
   - Fuel cells can eliminate pollution problems
   - The maintenance of fuel cells is simple since there are few moving parts in the system.

8. **What are the types of fuel cell? (Dec'11, Dec 07)**
   - Proton exchange membrane fuel cell
   - Alkaline fuel cell
   - Phosphoric acid fuel cell
   - Direct methanol fuel cell
   - Solid oxide fuel cell
   - Molten carbonate fuel cell

9. **What are the alternative fuels? (Dec'14, May'10, Dec 07)**
   Alcohols, Hydrogen, Natural Gas, CNG, LNG, LPG, Bio Gas, Producer Gas, Coke oven Gas, Water Gas, Gasohol, Biodiesel

10. **What are the disadvantages of using alcohol as an alternative fuel? (Dec'13, May'10)**
    A larger quantity of fuel is required to produce a specified power output. For example, in an automobile, more fuel is required for each mile driven.
    Low boiling points and high vapor pressures of methyl and ethyl alcohol indicate that vapor lock

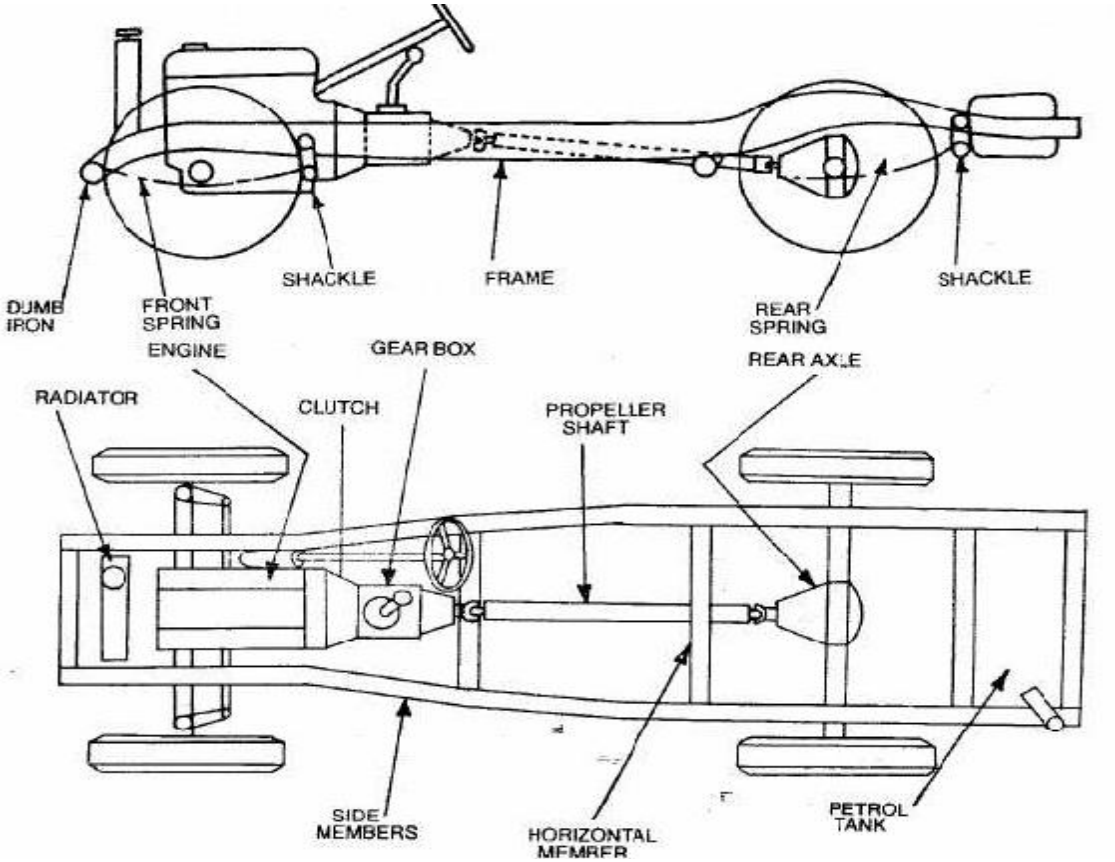
could be a serious problem, particularly at high altitudes on warm summer days.

PART – B
UNIT I
VEHICLE STRUCTURE AND ENGINES

1. Explain briefly the various types of chassis construction with the help of suitable diagrams and the types of frame with neat sketch. (Dec'14, May'10, Dec 07)

The main components of an automobile refer to the following components

- Frame,
- Chassis,
- Body,
- Power unit,
- Transmission system



An automobile is made up of mainly two units, these are Chassis and Body.

"Frame" + "Base components" = "Chassis"

"Chassis" + "Body" = "Vehicle"

Frame

The frame is the skeleton of the vehicle. It servers as a main foundation and base for alignment for the chassis.

Types

- Conventional frame,
- Semi integral frame;
- Integral or untidiest frame

Chassis

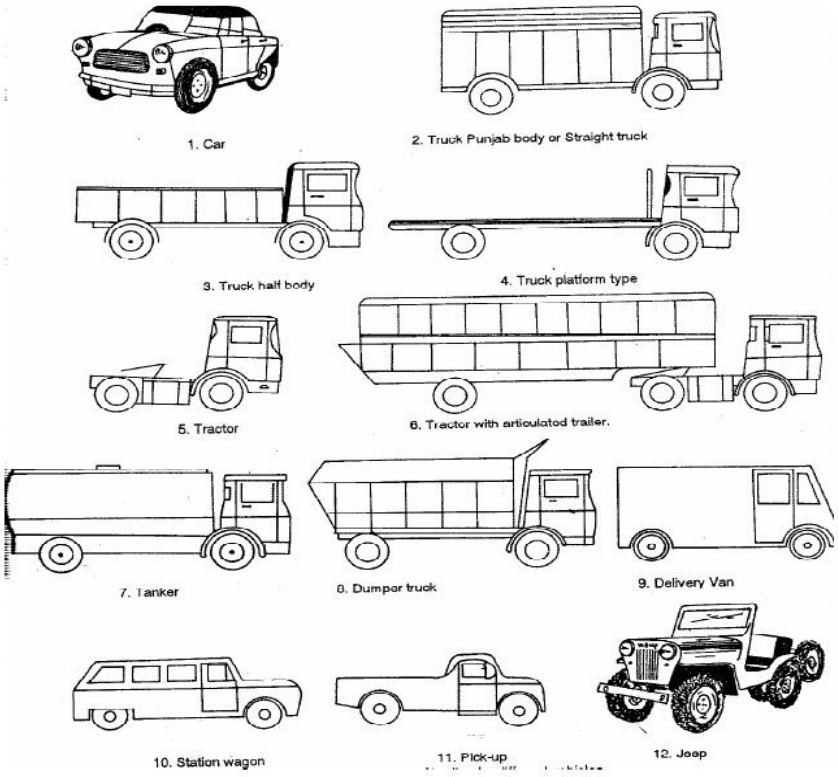
If the frame contains the base components its called as chassis. The components are like Engine, radiator, clutch, gearbox, silencer, road wheels, fuel tank, wirings, differential units, etc..,

Body:

Body is the superstructure of the vehicle and it is bolted to the chasis

Types

- Car,
- Truck,
- Tractor,
- Delivery van,
- Jeep,
- Bus, etc..,

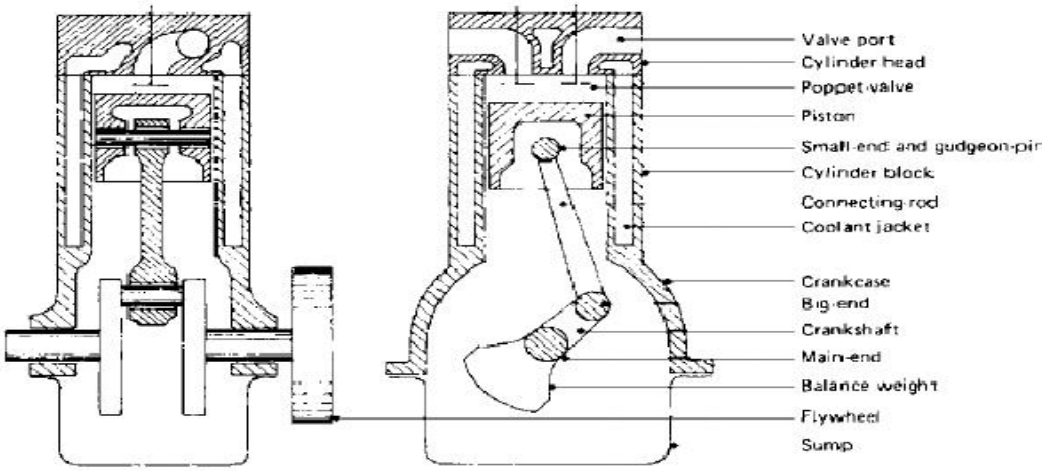


2. Discuss the forms, functions and materials of various components of an engine. (Dec'14, May'08)

The major components of the engine and their functions are briefly described below.

Definition of 'Engine'

An engine is a device, which transforms one form of energy into another form. Normally, most of the engines convert thermal energy into mechanical work and therefore they are called 'heat engines'



Cylinder Block

- The cylinder block is the main supporting structure for the various components.
- The cylinder of a multicylinder engine is cast as a single unit, called cylinder block.
- The cylinder head is mounted on the cylinder block.
- The cylinder head and cylinder block are provided with water jackets in the case of water cooling with cooling fins in the case of air-cooling.
- Cylinder head gasket is incorporated between the cylinder block and cylinder head.
- The cylinder head is held tight to the cylinder block by number of bolts or studs. The bottom portion of the cylinder block is called crankcase.
- A cover called crankcase, which becomes a sump for lubricating oil is fastened to the bottom of the crankcase.
- The inner surface of the cylinder block, which is machined and finished accurately to cylindrical shape, is called bore or face.

Cylinder

- As the name implies it is a cylindrical vessel or space in which the piston makes a reciprocating motion.
- The varying volume created in the cylinder during the operation of the engine is filled with the working fluid and subjected to different thermodynamic processes.
- The cylinder is supported in the cylinder block.

Piston

It is a cylindrical component fitted into the cylinder forming the moving boundary of the
combustion system. It fits perfectly (snugly) into the cylinder providing a gas-tight space with the piston rings and the lubricant. It forms the first link in transmitting the gas forces to the output shaft.

Combustion Chamber

The space enclosed in the upper part of the cylinder, by the cylinder head and the piston top during the combustion process, is called the combustion chamber. The combustion of fuel and the consequent release of thermal energy results in the building up of pressure in this part of the cylinder.

Inlet Manifold

The pipe which connects the intake system to the inlet valve of the engine and through which air or air-fuel mixture is drawn into the cylinder is called the inlet manifold.

Gudgeon Pin

It forms the link between the small end of the connecting rod and the piston.

Exhaust Manifold

The pipe that connects the exhaust system to the exhaust valve of the engine and through which the products of combustion escape into the atmosphere is called the exhaust manifold.

Inlet and Exhaust Valves

Valves are commonly mushroom shaped poppet type. They are provided either on the cylinder head or on the side of the cylinder for regulating the charge coming into the cylinder (inlet valve) and for discharging the products of combustion (exhaust valve) from the cylinder.

Connecting Rod

- It interconnects the piston and the crankshaft and transmits the gas forces from the piston to the crankshaft.
- The two ends of the connecting rod are called as small end and the big end. Small end is connected to the piston by gudgeon pin and the big end is connected to the crankshaft by crankpin.

Crankshaft

- It converts the reciprocating motion of the piston into useful rotary motion of the output shaft.
- In the crankshaft of a single cylinder engine there is pair of crank arms and balance weights.
- The balance weights are provided for static and dynamic balancing of the rotating system.
- The crankshaft is enclosed in a crankcase.

Piston Rings

Piston rings, fitted into the slots around the piston, provide a tight seal between the piston and the cylinder wall thus preventing leakage of combustion gases

Camshaft

- The camshaft and its associated parts control the opening and closing of the two valves.
- The associated parts are push rods, rocker arms, valve springs and tappets.
- This shaft also provides the drive to the ignition system.
- The camshaft is driven by the crankshaft through timing gears.

Cams

These are made *as* integral parts of the camshaft and are designed in such a way to open the valves at the correct timing and to keep them open for the necessary duration.

Fly Wheel

- The net torque imparted to the crankshaft during one complete cycle of operation of the engine fluctuates causing a change in the angular velocity of the shaft.
- In order to achieve a uniform torque an inertia *mass* in the form of a wheel is attached to the output shaft and this wheel is called the flywheel.

3. Explain the need of cooling system in automobiles. Mention its types (Dec'11, May'10)

Cooling system

The cooling system removes excess heat to keep the inside of the engine at an efficient temperature.

- Air Cooling
- Liquid Cooling
- Water cooling Coolant.

Water Jackets:

- Water Jackets Surrounds the cylinders with water passage.
- Absorbs heat from the cylinder wall.
- Pump move water to radiator where heat is exchanged to the air.

Coolant Flow:

- Coolant flows through the water jackets where it absorbs heat.
- It then flows through the radiator where heat is transferred to the air passing through.
- The amount of flow is determined by the water pump.
- The flow direction is controlled by the thermostat.

Warm Engine:

- The thermostat opens when the engine warms up.

- This allows coolant to circulate through the radiator and the water jackets.

Cold Engine:

When an engine is cold, the thermostat is cold. Coolant flow is through the bypass hose and the water jackets. This allows the engine to warm up evenly.

Coolant :

- Coolant Water (Boiling Point 100° C)
- Glycerin (Boiling Point 290 ° C)
- Ethylene glycol (Boiling Point 197 ° C)
- Antifreeze (methyl alcohol, ethyl alcohol)

Cooling System:

- Water pump is driven by the crankshaft through Timing Belt (Keeps Cam and Crank shafts in time)
- Drive/accessory Belt (Runs alternator, power-steering pump, AC, etc.) Serpentine Belt VBelt
- Electric fan is mounted on the radiator and is operated by battery power. It is controlled by the thermostat switch

Need for cooling system

The cooling system has four primary functions. These functions are as follows:

1. Remove excess heat from the engine.
2. Maintain a constant engine operating temperature.
3. Increase the temperature of a cold engine as quickly as possible.
4. Provide a means for heater operation (warming the passenger compartment).

Types of cooling system:

The different Types of cooling system are

1. Air cooling system
2. Liquid cooling system
3. Forced circulation system
4. Pressure cooling system

Air-Cooled System :

The simplest type of cooling is the air-cooled, or direct, method in which the heat is drawn off by moving air in direct contact with the engine Several fundamental principles of cooling are embodied in this type of engine cooling. The rate of the cooling is dependent upon the following:

1. The area exposed to the cooling medium.
2. The heat conductivity of the metal used & the volume of the metal or its size in cross section .
3. The amount of air flowing over the heated surfaces.
4. The difference in temperature between the exposed metal surfaces and the cooling air.

Liquid-cooled system;

Nearly all multi cylinder engines used in automotive, construction, and material handling equipment use a liquid-cooled system. Any liquid used in this type of system is called a COOLANT.

- A simple liquid-cooled system consists of a radiator, coolant pump, piping, fan, thermostat, and a system of water jackets and passages in the cylinder head and block through which the coolant circulates.
- Some vehicles are equipped with a coolant distribution tube inside the cooling passages that directs additional coolant to the points where temperatures are highest.
- Cooling of the engine parts is accomplished by keeping the coolant circulating and in contact with the metal surfaces to be cooled. The operation of a liquid- cooled system is as follows:
- The pump draws the coolant from the bottom of the radiator, forcing the coolant through the water jackets and passages, and ejects it into the upper radiator tank.
- The coolant then passes through a set of tubes to the bottom of the radiator from which the cooling cycle begins.
- The radiator is situated in front of a fan that is driven either by the water pump or an electric motor.

- The fan ensures airflow through the radiator at times when there is no vehicle motion.
- The heating in the engine and the cooling in the radiator therefore create a natural circulation that aids the water pump.

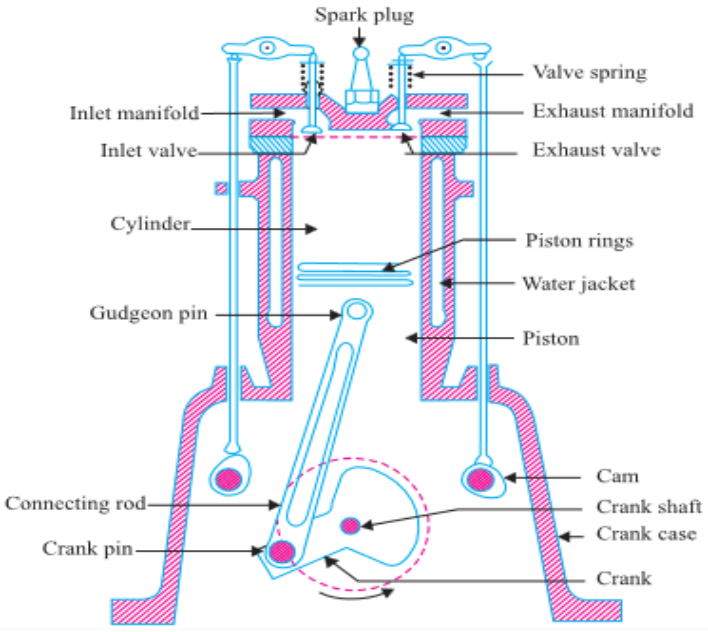
4. **With the help of neat sketch explain in details and the construction and working of different engine components? (May 2012)**

An engine comprises of a few hundred components: small and big, stationary and moving, metallic and non-metallic, casted and .forged and made by other processes. The components of an engine can be grouped under two categories.

1. Stationary or Structure forming components, and

2. Moving or Mechanism forming components

The stationary components constitute the structural parts and the moving components synthesize the mechanism parts of an engine. Important components among these are listed below.

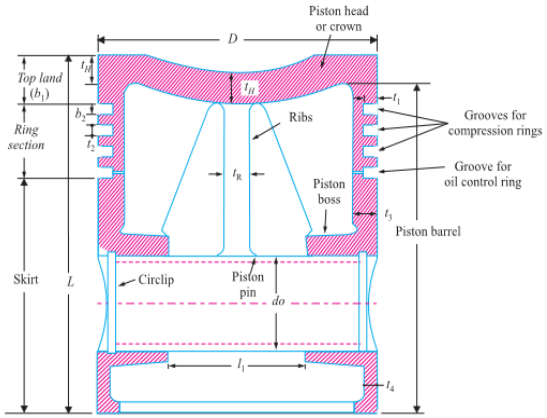


- Engine block.
- Pistons.
- Rings.
- Connecting rods.
- Crankshaft.
- Cylinder heads.
- Valves and related components.
- Balance shafts

Engine Block:

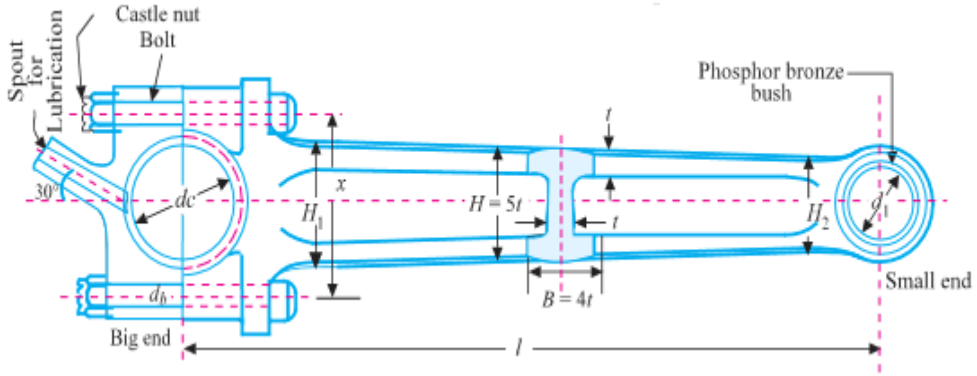
The engine block is the basic support and attaching point for all other engine parts. Engine blocks are made by pouring molten cast iron, steel, or aluminum into molds, . After the metal cools, the molding sand is washed out and the block is machined to allow other parts to be installed or attached. The major parts installed in or on the block are the pistons, crankshaft, camshaft, cylinder heads, and manifolds

Pistons and Rings:



Pistons transfer the force of expanding combustion gases to the connecting rods. They are made of aluminum to reduce weight. Most automotive pistons have two compression rings and one oil ring. Compression rings seal in the pressure created during the compression and power strokes. If this pressure is allowed to leak out, the engine will not start or will have severe power and driveability problems. The compression rings are installed at the top of the piston. A film of oil between the compression ring and cylinder wall seals pressure in the cylinder.

Connecting Rods and Crankshaft:

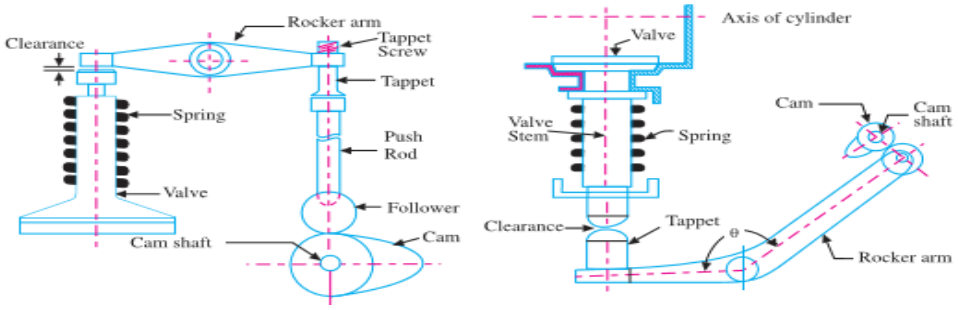


The connecting rods are forged steel rods that connect the piston to the crankshaft. They transfer the force from the piston to the crankshaft. Each connecting rod is connected to a piston by a piston pin. The rod is attached to the crank shaft by a bearing cap and bearing inserts that surround the crankshaft journal. The piston pin and crankshaft bearings allow the rod to move in relation to both the piston and crankshaft. The crankshaft converts the straight-line force from the piston and connecting rod into rotary force. It is attached to the engine block by bearing caps and bearings that surround the crankshaft journal. This design allows the crankshaft to rotate inside of the bearings with minimal friction.

Cylinder Heads:

The cylinder head contains the combustion chamber for each cylinder and forms the top of the cylinder. Cylinder heads contain the intake and exhaust valves and, in some cases, the camshaft and lifters. They also contain oil galleries, coolant passages, and openings to allow the flow of intake and exhaust gases

Valves and Related Components:



One or more intake valves are used to control the flow of the air into each cylinder. One or more exhaust valves are used to control the flow of exhaust gases out of each cylinder. Valves also seal the cylinder during the compression and power strokes. They are occasionally called mushroom valves due to their resemblance to a mushroom. Intake and exhaust valves are identical in shape, but intake valves are usually larger. Opening and closing of the valves are controlled by the valve train. The valve spring holds the valve against its seat, keeping it closed. Valve springs are always slightly compressed when installed. This ensures that the valve closes tightly.

Push Rods and Rocker Arms:

Push rods are used only on cam-in-block engines. They transmit the lifter motion to the rocker arm. Many push rods are hollow. Oil from the lifter flows through them to lubricate the rest of the valve train. Rocker arms are pivoting levers that convert the upward movement of the push rod or lifter into downward movement of the valve

Balance Shafts:

In some engines, one or more balance shafts are added to counterbalance vertical and torsional vibrations. A balance shaft has offset weights that rotate in the opposite direction of the crankshaft. These shafts are either turned by the camshaft through direct gearing or by the crankshaft through a belt or chain. Balance shafts help to provide a smoother idle and less vibration from the engine.

5. Discuss the principle of operation of a four stroke cycle S.I.Engine with a neat sketch.
(Dec'08, May'10,)

- In a four-stroke engine, the cycle of operations is completed in four strokes of the piston or two revolutions of the crankshaft.
- During the four strokes, there are five events to be completed, viz, suction, compression, combustion, expansion and exhaust.
- Each stroke consists of 180° of crankshaft rotation and hence a four-stroke cycle is completed through 720° of crank rotation.
- The cycle of operation for an ideal four-stroke SI engine consists of the following four strokes:
  i. Suction or intake stroke;
  ii. Compression stroke;

iii. Expansion or power stroke and
iv. Exhaust stroke.

Working principle of a Four Stroke SI Engine

Suction or Intake Stroke:

- Suction stroke starts when the piston is at the top dead centre and about to move downwards.
- The inlet valve is open at this time and the exhaust valve is closed.
- Due to the suction created by the motion of the piston towards the bottom dead centre, the charge consisting of fuel-air mixture is drawn into the cylinder.
- When the piston reaches the bottom dead centre the suction stroke ends and the inlet valve closes.

Compression Stroke:

- The charge taken into the cylinder during the suction stroke is compressed by the return stroke of the piston.
- During this stroke both inlet and exhaust valves are in closed position.
- The mixture that fills the entire cylinder volume is now compressed into the clearance volume.
- At the end of the compression stroke the mixture is ignited with the help of a spark plug located on the cylinder head.
- In ideal engines it is assumed that burning takes place instantaneously when the piston is at the top dead centre and hence the burning process can be approximated as heat addition at constant volume.

iii. Expansion stroke or Power stroke:

- During the burning process the chemical energy of the fuel is converted into heat energy producing a temperature rise of about 2000 °C.
- The pressure at the end of the combustion process is considerably increased due to the heat release from the fuel

iv. Exhaust Stroke:

- At the end of the expansion stroke the exhaust valve opens and the inlet valve remains closed.
- The pressure falls to atmospheric level a part of the burnt gases escape.
- The piston starts moving from the bottom dead centre to top dead centre and sweeps the burnt gases out from the cylinder almost at atmospheric pressure.
- The exhaust valve closes when the piston reaches T.D.C. at the end of the exhaust stroke and some residual gases trapped in the clearance volume remain in the cylinder.
- Residual gases mix with the fresh charge coming in during the following cycle, forming its working fluid.
- Each cylinder of a four stroke engine completes the above four operations in two engine revolutions, one revolution of the crankshaft occurs during the suction and compression strokes and the second revolution during the power and exhaust strokes.
- Thus for one complete cycle there's only one power stroke while the crankshaft turns by two revolutions.

6. **. Explain the various forces acting on a body of automobile and its aerodynamic effects.**

The resistances can be categorized into the following categories:

1. Aerodynamic drag
2. Gradient resistance
3. Rolling resistance

All the above produce a restraining force working against the tractive force. The tractive force must be greater than or equal to the resistive forces in order to maintain a sustainable motion. We can balance them as

$F = F_{req} = F_A + F_G + F_R + F_I$

Where FA= Force due to air resistance FG = Force due to gradient of a slope FG = Force due to rolling resistance FI = Force due to moving or static inertia The last one FI comes into the picture only when the vehicle accelerates or decelerates, while the first three always offer a resistance even when the vehicle is moving at a constant speed.

Air resistance/ Aerodynamic drag:

When a body travels within a dense medium, the molecules of the medium collide with the moving object and thereby absorb some of the energy. This is felt as a resistance to the moving object. If the medium is denser, then the resistance is more.

Also when the object moves at a faster speed, the resistance increases proportionately. Mathematically it can be expressed as:

$F_A = -\frac{1}{2} \times C_d \times P \times V^2$

Where Cd = Co−efficient of discharge, P = Pressure, V = Velocity of the vehicle

Gradient resistance

A truck moving uphill When the vehicle travels uphill, a component of its weight works in a direction opposite to its motion. If some energy is not supplied to overcome this backward force, then the vehicle would slow down, stall and roll backwards. If the vehicle is trading uphill at a slope of θ, then the weight of the vehicle, W has two components: one perpendicular to the road surface (with a value $W \cdot \cos\theta$) and the other along the road surface (with a value $W \cdot \sin\theta$). The component along the road surface is the one that tries to restrict the motion.

The gradient resistance is given by: $F_G = W \cdot \sin\theta$

Rolling resistance

When a vehicle rolls, it rolls with its tires in contact with the road surface. The relative motion of two hard surfaces produces a friction. Further, neither the road, nor the tires are perfectly rigid. Hence, both flex under the load slightly. As there is a gradual deformation at the contact between the road and the tire, greatest at the bottom most point and least at the entry and exit points, the slip of the tire w.r.t. the road produces another type of loss of energy which results in a resistance. Rolling resistance is composed of the following components:

- Tire Rolling resistance: $F_{R,T}$
- Road rolling resistance: $F_{R,Tr}$
- Resistance due to tire slip angle: $F_{R,\alpha}$
- Resistance due to bearing friction and residual braking: $F_{R,fr}$

Hence the rolling resistance offered may be written as:

$F_R = F_{R,T} + F_{R,Tr} + F_{R,\alpha} + F_{R,fr}$

The tire rolling resistance $F_{R,T}$ is a result of the resistance due to flexure of the tire, air resistance on the tire and friction of tire with the road.

These three can be summed up and written as:

FR,T = FR.T.flex + FR.T.A + FR.T.fr.

In a simplified manner the total rolling resistance can be related to the vertical load on the wheels and can be written as:

Co−efficient of rolling friction, kR = FR/FZ.w

PART – B
UNIT II
ENGINE AUXILIARY SYSTEMS

1. With a neat sketch explain the working of a multi point fuel injection system in diesel engines.

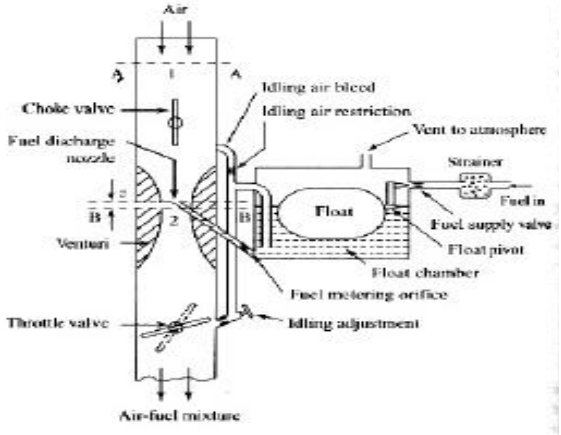
(Dec'13, May'10)

Carburetion

- Spark-ignition engines normally use volatile liquid fuels.
- Preparation of fuel-air mixture is done outside the engine cylinder and formation of a homogeneous mixture is normally not completed in the inlet manifold.
- The process of mixture preparation is extremely important for spark-ignition engines.
- The purpose of carburetion is to provide a combustible mixture of fuel and air in the required quantity and quality for efficient operation of the engine under all conditions.

The Simple Carburetor

- Carburetors are highly complex.
- The simple carburetor mainly consists of a float chamber, fuel discharge nozzle and a metering orifice, a venturi, a throttle valve and a choke.
- The float and a needle valve system maintain a constant level of gasoline in the float chamber.
- If the amount of fuel in the float chamber falls below the designed level, the float goes down, thereby opening the fuel supply valve and admitting fuel.
- When the designed level has been reached, the float closes the fuel supply valve thus stopping additional fuel flow from the supply system.
- Float chamber is vented either to the atmosphere or to the" upstream side of the venturi.
- During suction stroke air is drawn through the venturi.

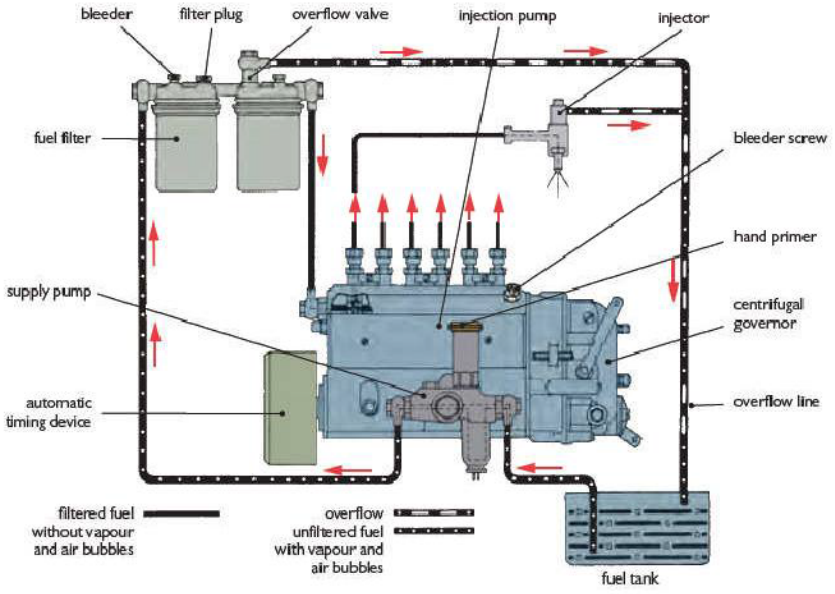


- The gasoline engine is quantity governed, which means that when power output is to be varied at a particular speed, the amount of charge delivered to the cylinder is varied.

- This is achieved by means of a throttle valve usually of the butterfly type that is situated after the venturi tube.
- As the throttle is closed less air flows through the venturi tube and less is the quantity of air fuel mixture delivered to the cylinder and hence power output is reduced.
- As the throttle is opened, more air flows through the choke tube resulting in increased quantity of mixture being delivered to the engine. This increases the engine power output.
- A simple carburetor of the type described above suffers from a fundamental drawback in that it provides the required A/F ratio only at one throttle position.
- At the other throttle positions the mixture is either leaner or richer depending on whether the throttle is opened less or more.
- As the throttle opening is varied, the air flow varies and creates a certain pressure differential between the float chamber and the venturi throat.
- The same pressure differential regulates the flow of fuel through the nozzle.
- Therefore, the velocity of flow of air II and fuel vary in a similar manner.

Working Principle

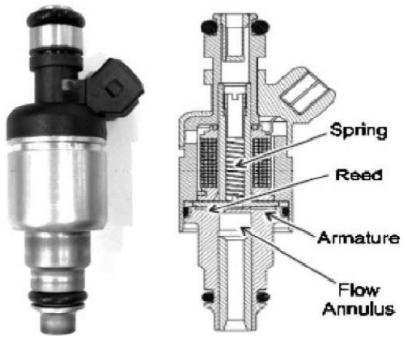
- The injection of fuel or the quantity of injected fuel has a decisive influence on engine starting, idling, power and emissions.
- The engine ECU is programmed with relevant data to where the fuel rack position has an equivalent signal for the amount of fuel being injected.
- The driver requests the torque or engine speed requirements via accelerator pedal potentiometer thereby sending a signal to the engine ECU
- The driver can also input additional commands such as idle speed increase to compensate e.g. for PTO operation which can be either variably set or has a preset speed which can be recalled.
- The road speed function can be used to evaluate vehicle speed and possibly activate a speed limiter (Heavy Vehicles), or maintain or restore a set speed (cruise control).
- Further functions can include exhaust brake operation which, when activated, will result in the fuel pump rack position being set to zero delivery or idle.
- The engine ECU can also interface with various other vehicle systems e.g. traction control and carries out self monitoring duties and self diagnostic functions to keep the system working at an optimal level.
- To ensure the safe operation in case of failure, the limp home mode functions are also integrated into the system, for e.g. should the pump speed sensor fail the ECU can use an alternator speed signal function for engine RPMs counter as a backup signal.



Fuel Injector

- Fuel injection is a system for admitting fuel into an internal combustion engine.

- A variety of injection systems have existed since the earliest usage of the internal combustion engine.
- The primary difference between carburetors and fuel injection is that fuel injection atomizes the fuel by forcibly pumping it through a small nozzle under high pressure, while a carburetor relies on suction created by intake air accelerated through a Venturi tube to draw the fuel into the airstream.
- Modern fuel injection systems are designed specifically for the type of fuel being used.
- Some systems are designed for multiple grades of fuel (using sensors to adapt the tuning for the fuel currently used).
- Most fuel injection systems are for gasoline or diesel applications



2. **With a neat sketch explain the working of a battery coil and magneto coil ignition system.**

(Dec'11, May'13)

Introduction of Ignition System

- For petrol engine - Battery ignition system , Magneto ignition system Injection system
- For diesel engine - Fuel supply system.

Battery ignition system

Battery ignition system has the following elements

- Primary Ignition Circuit(low voltage)
- Battery
- Ignition switch
- Primary windings of coil
- Contact breaker
- capacitor
- Secondary Ignition Circuit (high voltage)
- Secondary windings of coil
- Distributor cap and rotor (if the vehicle is so equipped)
- Spark plug wires &
- Spark plugs

- In all spark ignition engines which work on the Gasoline either 2-Stroke or 4-Stroke cycle principle and utilize a carburetor or fuel injection system, the combustion of the air-fuel mixture is initiated by an electric spark.
- The term 'Spark Ignition' means that a brief electric arc is produced between the electrodes of a spark plug, the energy for which is derived from an external power source.
- A different method of ignition is employed in diesel engines.
- This is called 'compression ignition' and relies on the fact that when air compressed, its temperature rises.
- In diesel engines, compression ratio of between 16:1 and 25:1 are common, and at the end of a compression the temperature of the trapped air is sufficiently high to ignite the diesel fuel that is sprayed into the cylinder at the appropriate time.

The functions of ignition system

The functions of the coil ignition systems in general use on motor vehicle may be divided into three areas. These are:

- Production of the high voltage necessary to produce a spark at the plug gap.
- Distribute the spark to all the cylinders at proper time based on the firing order.
- Varying the timing of the spark depending on the various operating conditions of the engine like cranking time, varying speed and load, so that the best performance is obtained from the engine under all operating conditions.

Mechanism of Ignition

- The vehicle battery voltages are usually 12 volt or 24 volt and this value is too low to produce a heavy spark at the plug gap in a cylinder under compression.
- One of the major functions of the battery ignition system is to raise the battery voltage to the required level and then apply it to spark plugs.
- This process is correctly initiated in the primary circuit and completed in the secondary winding of the ignition coil.
- Depending on the type of engine and the conditions existing in the cylinders, a voltage of between 5,000 to 20,000 volts is required and this is called the **ionizing voltage** or **firing voltage.**
- This firing voltage forces the electrons to jump between the electrodes of the spark plug in the gap to produce the required spark.
- The electric spark has sufficient heat energy to ignite the air fuel mixture which later continues to burn itself.

The conventional coil ignition system

Inductive ignition systems: that uses an **ignition coil** to perform the step up transformer action and to increase the electrical voltage. The ignition coils of the inductive ignition systems operate on the principle of electromagnetic induction (EMI) irrespective of whether it is triggered by contact breakers or by electronic triggering units.

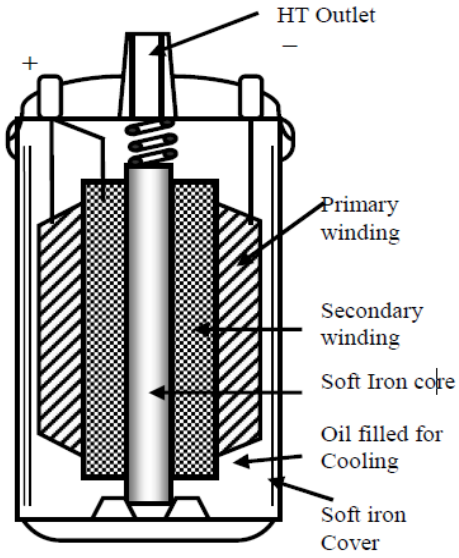
The factors affecting the operation of the Ignition system.

The factors that determine the value of the voltages induced into the ignition coil windings during the ignition cycle are:

(a) The strength of the magnetic field. The stronger the magnetic field produced in the coil primary winding, the greater the possibility of producing a high secondary voltage.

(b) The number of conductors on the secondary winding being cut by the magnetic field. This Is important when considering the voltages produced in both coil windings during the ignition cycle.

(c) The speed of relative movement between the magnetic field and the conductors. The faster the magnetic field can be made to cut the conductors, the higher will be the value of voltage induced into the coil windings.



Ignition Coil

Construction of the Ignition coil

The source of the high voltage pulses of current produced in the inductive ignition system is in the ignition coil. The coil stores the energy in the magnetic field around the primary winding and at the required instant of ignition, transforms it into a pulse of high voltage current in the secondary winding. From here it is delivered to the correct spark plug via the high tension (HT) cables. This 'Inductive storage device' may vary in design between certain manufacturers, but in general the most common construction.

This coil contains a rod shaped, laminated soft iron core at its centre, and the soft iron cover surrounds both primary and secondary windings. Both of these soft iron components are used to intensify and maximize the effect of the primary magnetic field and thus, the energy stored. The iron core must be laminated to minimize the effects of eddy currents that are produced during operation and so keep to a minimum the heat developed. The outer soft iron cover is slotted to allow circulation of the oil filling which is used for cooling purposes.

3. With a neat sketch explain the working of a common rail direct injection system in diesel engines. (Dec'14, May'10, Dec 08)

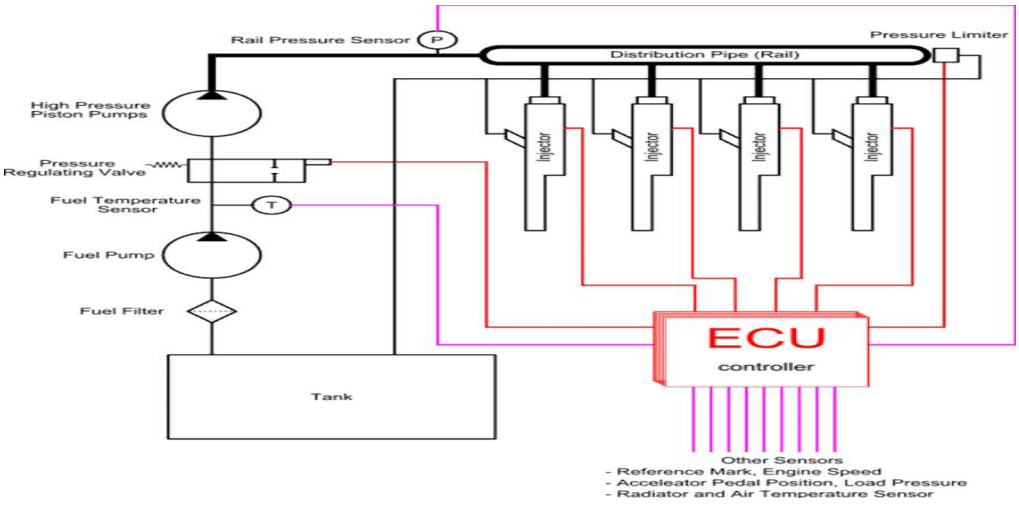
CRDI - Common rail fuel injection system

- Common rail direct fuel injection is a modern variant of direct fuel injection system for petrol and diesel engines.
- On diesel engines, it features a high-pressure (100 MPa or 15,000 psi) fuel rail feeding individual solenoid valves, as opposed to low-pressure fuel pump feeding unit injectors (or pump nozzles).
- Third-generation common rail diesels now feature piezoelectric injectors for increased precision, with fuel pressures up to 3,000 bar (300 MPa; 44,000 psi).

Working Principle

- Solenoid or piezoelectric valves make possible fine electronic control over the fuel injection time and quantity, and the higher pressure that the common rail technology makes available provides better fuel atomisation.
- To lower engine noise, the engine's electronic control unit can inject a small amount of diesel just before the main injection event, thus reducing its explosiveness and vibration, as well as optimising injection timing and quantity for variations in fuel quality, cold starting and so on.
- Some advanced common rail fuel systems perform as many as five injections per stroke.
- Diesel engines have used various forms of fuel injection. Two common types include the unit injection system and the distributor/inline pump systems.
- While these older systems provided accurate fuel quantity and injection timing control, they were limited by several factors:
- They were limited in the number and timing of injection events that could be commanded during a single combustion event.

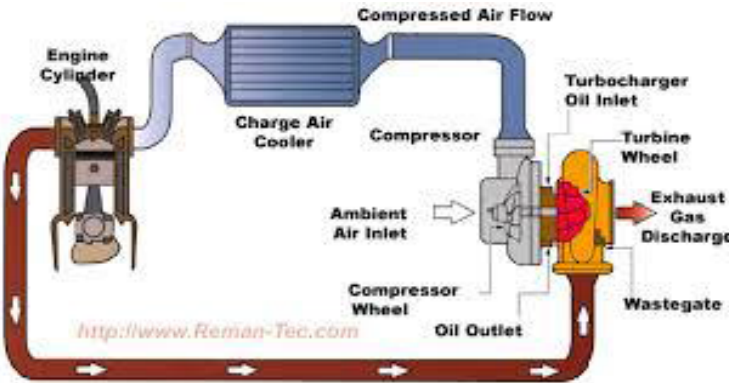
- For the typical distributor/inline system, the start of injection occurred at a pre-determined pressure and ended at a pre-determined pressure.
- Once the pressure in the injector reached a pre-determined level, the plunger would lift and injection would start.



4. Draw a neat sketch of turbocharger. Explain it. (Dec'12, May'11)

Turbocharger

- The turbo charger utilizes the wasted heat energy in the exhaust system, to run a compressor which compresses the intake air.
- Compressed intake air has more density and hence more fuel can be injected increasing the power of the engine.
- Turbo charging is an ideal way to increase the engine power without increasing the engine size.
- Turbochargers were originally known as turbo superchargers when all forced induction devices were classified as superchargers.
- The key difference between a turbocharger and a conventional supercharger is that the latter is mechanically driven by the engine, often through a belt connected to the crankshaft, whereas a turbocharger is powered by a turbine driven by the engine's exhaust gas.
- Compared to a mechanically driven supercharger, turbochargers tend to be more efficient, but less responsive.
- They are most often used with Otto cycle and Diesel cycle internal combustion engines.



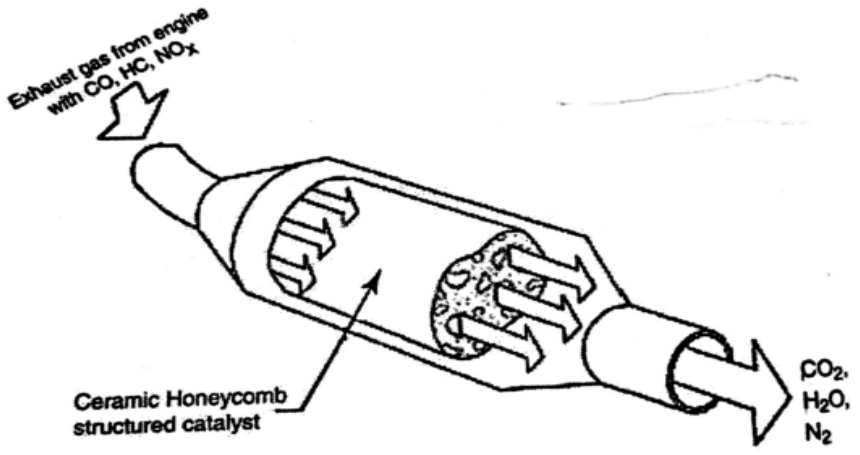
5. With a neat sketch explain the working features of 3 way catalytic converter system. (Dec'11, May'08)

Catalytic converter

Catalytic converter is a vehicle emissions control device that converts toxic pollutants in exhaust gas to less toxic pollutants by catalyzing a redox reaction(oxidation or reduction). Catalytic converters are used in internal combustion engines fueled by either petrol (gasoline) or diesel including lean burn engines.

Construction of a catalytic converter

- The principle of the catalyst converter package is to control the emission levels of various pollutants by changing the chemical characteristic of the exhaust gasses.
- It can control HC and CO emissions almost completely at temperatures equivalent to normal exhaust gas temperature
- Thus the losses in fuel economy necessary to increase the exhaust temperature is avoided. Catalyst materials,e.g platinum or palladium, are applied to a ceramic support which has been treated with an aluminum oxide wash coat .
- This results in an extremely porous structure providing a large surface area to simulate the combination of oxygen with HC and CO.
- The oxidation process converyts most of these components to water vapour and carbon dioxide. The schematic diagram of a catalytic package. Converters hydrocarbons, CO and NOx are arranged. The catalysts used for these converters are closely guarded secrets.
- The catalyst for NOx is the first element in the gas flow path and does not cause any heat release. The HC/CO catalyst is the next. Its heat release is so great that there is a risk of over experiments with various types of converters have led to the conclusion that the axial flow form is superior to the radial floe type.
- Three- way monolith catalyst converter. The front bed or inlet, is treated with platinum and rhodium and is termed a reducing catalyst. The rear bed is coated with palladium and is reffered to as the oxidizing catalyst.
- In exhaust gases first pass through the reducing catalyst. This causes the levels of NOx to be reduced. Pressurised air from the air injection system is forced in to the space between the catalyst beds. The extra air supplies additional oxygen and causes greater oxidation of the gases.
- As the treated exhaust gases from the first bed continue flowing, they eventually pass through the conventional oxidation catalyst made of palladium and platinum. Here hydrocarbons and carbon monoxide emissions are reduced



UNIT-III
TRANSMISSION SYSYTEMS

1. **What are the features of good quality clutch? Explain the working of multi plate clutch with a neat sketch. (Dec'10,11,May'08)**

Clutch:

- Clutch is a device which is used in the transmission system of automobile to engage and disengage the engine to the transmission or gear box.
- It is located between the transmission and the engine.
- When the clutch is engaged, the power flows from the engine to the rear wheels in a rearwheel-drive transmission and the vehicle moves.
- When the clutch is disengaged, the power is not transmitted from the engine to the rear wheels and vehicle stops even if engine is running.
- It works on the principle of friction.
- When two friction surfaces are brought in contact with each other and they are united due to the friction between them. If one is revolved the other will also revolve.

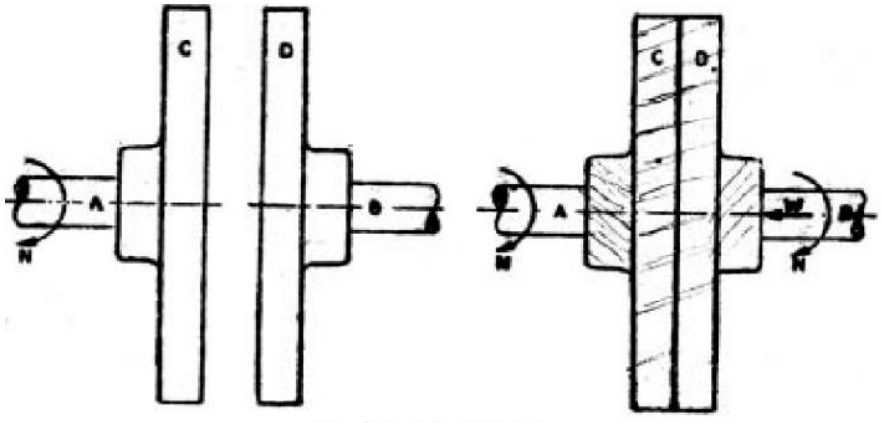


Fig: Principle of Clutch

- The friction depends upon the surface area contact.

- The friction surfaces are so designed that the driven member initially slips on driving member when initially pressure is applied.
- As pressure increases the driven member is brought gradually to speed the driving member.

The three main parts of clutch are:

- Driving member
- Driven member
- Operating member

- The driving member consists of a flywheel mounted on the engine crank shaft.
- The flywheel is bolted to cover which carries a pressure plate or driving disc, pressure springs and releasing levers.
- Thus the entire assembly of flywheel and cover rotates all the times.
- The clutch housing and the cover provided with openings dissipate the heat generated by friction during the clutch operation.
- The driving member consists of a disc or plate called clutch plate.
- It is free to slide length wise on the splines of the clutch shaft.
- It carries friction materials on both of its surfaces when it is gripped between the flywheel and the pressure plate; it rotates the clutch shaft through splines.
- The operating members consists of a foot pedal, linkage, release or throw-out bearing, release levers and springs necessary to ensure the proper operation of the clutch.
- Now the driving member in an automobile is flywheel mounted on crank shaft, the driven member is the pressure plate mounted on transmission or gear box input shaft.

Multi-plate Clutch:

- Multi-plate clutch consists of a number of clutch plates instead of only one clutch plate as in case of single plate clutch.
- As The number of clutch plates are increased, the friction surfaces also increases.
- The increased number of friction surfaces obliviously increases the capacity of the clutch to transmit torque.
- The plates are alternately fitted to engine and gear box shaft.
- They are firmly pressed by strong coil springs and assembled in a drum.
- Each of the alternate plate slides on the grooves on the flywheel and the other slides on splines on the pressure plate.
- Thus, each alternate plate has inner and outer splines.
- The multi-plate clutch works in the same way as a single plate clutch by operating the clutch pedal.
- The multi-plate clutches are used in heavy commercial vehicles, racing cars and motor cycles for transmitting high torque.
- The multi-plate clutch 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 clutch is used in conjunction with or part of the automatic transmission.

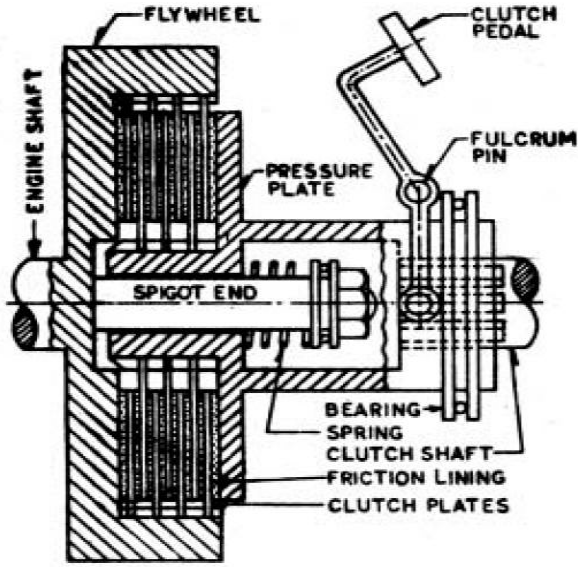


Fig : Multi-Plate Clutch

2. Describe the construction and operation of synchromesh gear box. . (Dec'14, May'10, Dec 07)

Syncromesh Gear Box:

- In sliding Mesh Gear box the two meshing gears need to be revolve at equal peripheral speeds to achieve a jerk less engagement and it is true for constant mesh gear box in which the peripheral speeds of sliding dog and the corresponding gear on the output shaft must be equal.
- The peripheral speed is given by, Where d1 and N1 are pitch circle diameter and r.p.m. of gear and d2 andN2 diameter and r.p.m. of attached dog respectively. Now $N1 \neq N2$ since $d1 \neq d2$.
- Thus there is a difference in gear and dog which necessitates double declutching.
- The driver has to disengage the clutch twice in quick succession therefore it is referred as double declutching. There are two steps involved in this process:
- The clutch is disengaged i.e. first declutching and the gear system is placed in its neutral position
- Now the clutch is reengaged and acceleration pedal is pressed to adjust the engine speed according to driver's judgment.The clutch is disengaged(i.e. second declutching) again the appropriate gear is engaged and then the clutch is reengaged
- It is that gear box in which **sliding synchronizing units** are provided in place of sliding dog clutches as in case of constant mesh gear box.
- With the help of synchronizing unit, the speed of both the driving and driven shafts is synchronized before they are clutched together through train of gears.
- The arrangement of power flow for the various gears remains the same as in constant mesh gear box. The synchronizer is made of frictional materials.
- When the collar tries to mesh with the gear, the synchronizer will touch the gear first and use friction force to drive the gear to spin at the same speed as the collar. This will ensure that the collar is meshed into the gear very smoothly without grinding.
- Synchromesh gear devices work on the principle that two gears to be engaged are first bought into frictional contact which equalizes their speed after which they are engaged readily and smoothly.

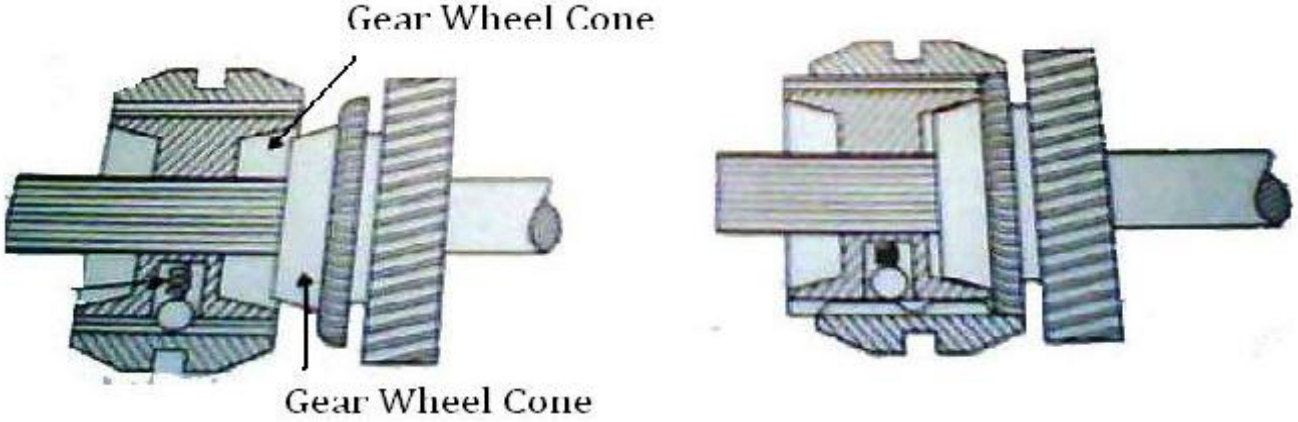


Fig: Synchro Mesh Unit

3. Explain and detail bout Differential Unit with neat sketch. (Dec'15, May'14, Dec 10)

- Differentials are a variety of gearbox, almost always used in one of two ways.
- In automobile and other wheeled vehicles, the differential allows each of the driving wheels to rotate at different speeds, while supplying equal torque to each of them.
- **Purpose**

The differential gear box has following functions:

- Avoid skidding of the rear wheels on a road turning.
- Reduces the speed of inner wheels and increases the speed of outer wheels, while drawing a curve.
- Keeps equal speeds of all the wheels while moving on a straight road.
- Eliminates a single rigid rear axle, and provides a coupling between two rear axles.

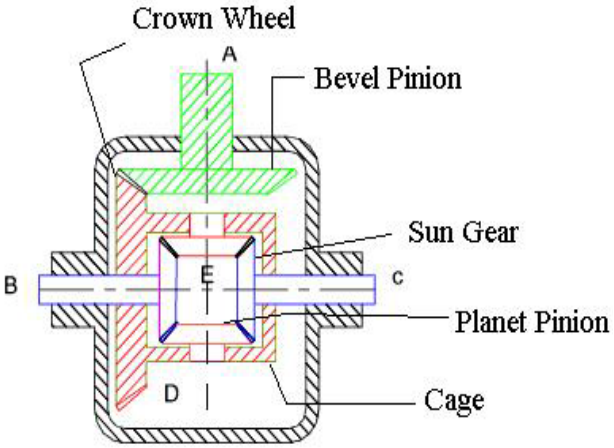
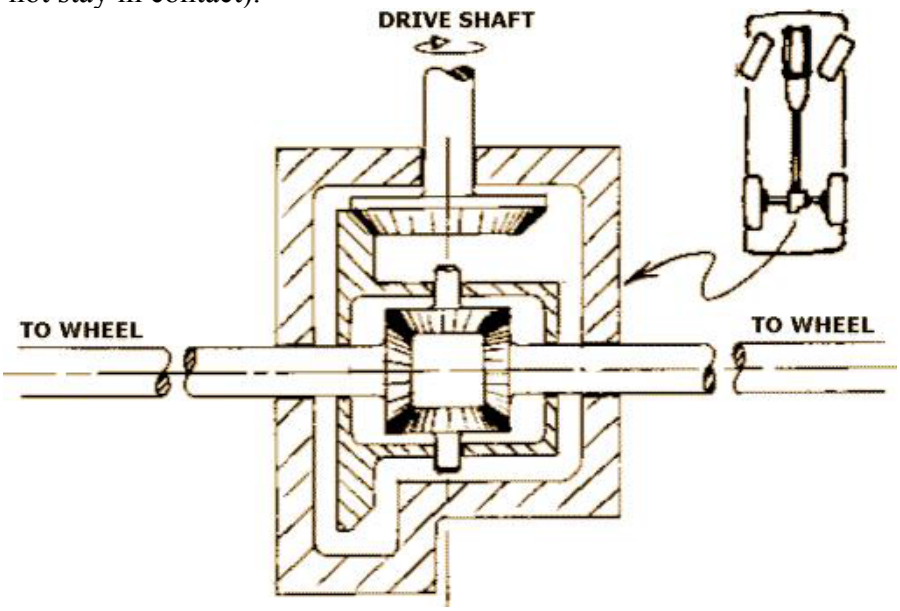


Fig: Differntial gear Assembly

The following description of a differential applies to a front-wheel-drive car or truck:

- Power is supplied from the engine, via the transmission or gearbox, to a drive shaft termed as propeller shaft, which runs to the differential.
- A spiral bevel pinion gear at the end of the propeller shaft is encased within the differential itself, and it meshes with the large spiral bevel ring gear termed as crown wheel.
- The ring gear is attached to a carrier, which holds what is sometimes called a spider, a cluster of four bevel gears in a rectangle, so each bevel gear meshes with two neighbors and rotates counter to the third that it faces and does not mesh with.
- Two of these spider gears are aligned on the same axis as the ring gear and drive the half shafts connected to the vehicle's driven wheels.

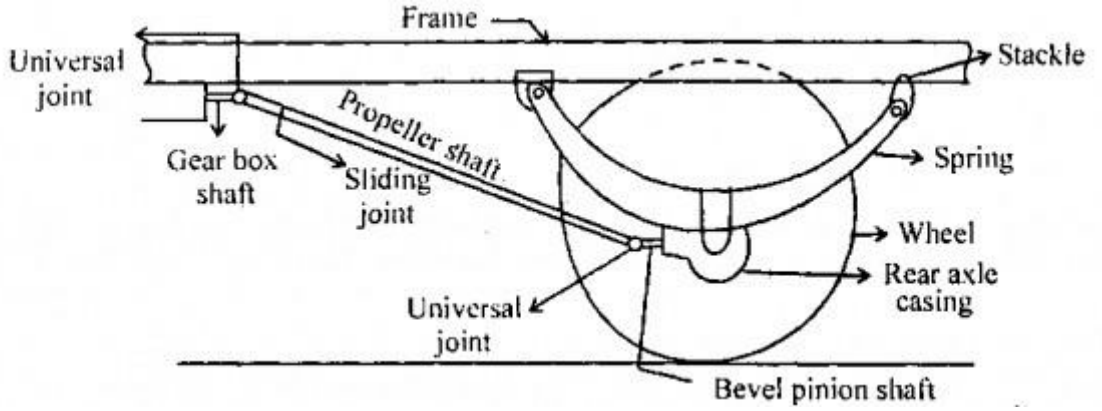
- The other two spider gears are aligned on a perpendicular axis which changes orientation with the ring gear's rotation.
- These two gears are just called pinion gears, not to be confused with the main pinion gear.
- As the carrier rotates, the changing axis orientation of the pinion gears imparts the motion of the ring gear to the motion of the side gears by pushing on them rather than turning against them, but because the spider gears are not restricted from turning against each other, within that motion the side gears can counter-rotate relative to the ring gear and to each other under the same force (in which case the same teeth do not stay in contact).



4. Explain and detail about the Hotchkiss Drive mechanism and Torque tube Drive mechanism with neat sketch. (Dec'14, May'10)

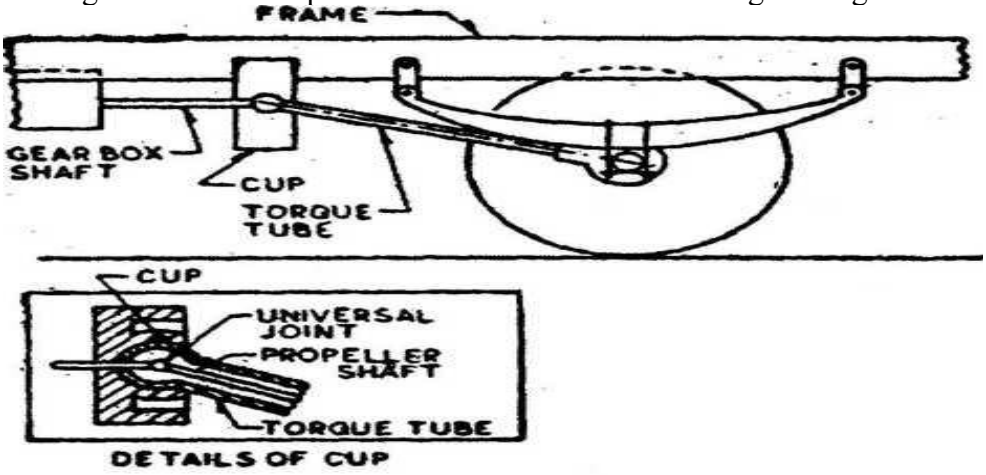
- The Hotchkiss drive is a system of power transmission.
- All shaft-drive systems consist of a driveshaft extending from the transmission in front to the differential in the rear.
- The differentiating characteristic of the Hotchkiss drive is the fact that it uses universal joints at both ends of the driveshaft, which is not enclosed.
- The use of two universal joints, properly phased and with parallel alignment of the drive and driven shafts, allows the use of simple crosstype universals. (In a torque-tube arrangement only a single universal is used at the end of the transmission tail shaft, and this universal should be a constant velocity joint.)
- In the Hotchkiss drive, slip-splines or a plunge-type eliminate thrust transmitted back up the driveshaft from the axle, allowing simple rear-axle positioning using parallel leaf springs. (In the torque-tube type this thrust is taken by the torque tube to the transmission and thence to the transmission and motor mounts to the frame.
- While the torque-tube type requires additional locating elements, such as a Panhard rod, this allows the use of coil springs.)
- Some Hotchkiss drive shafts are made in two pieces with another universal joint in the center for greater flexibility, typically in trucks and specialty vehicles built on truck frames. Some installations use

rubber mounts to isolate noise and vibration.



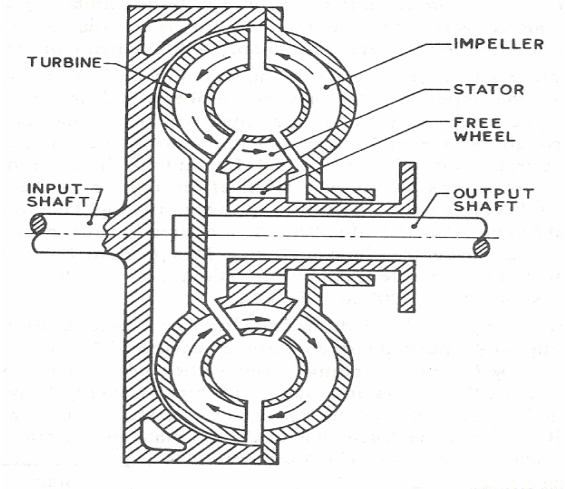
Torque tube Drive mechanism

- A torque tube system is a driveshaft technology, often used in automobiles with a front engine and rear drive. It is not as widespread as the Hotchkiss drive, but is still occasionally used to this day. Drive shafts are sometimes also used for other vehicles and machinery.
- The "torque" that is referred to in the name is not that of the driveshaft, along the axis of the car, but that applied by the wheels. The design problem that the torque tube solves is how to get the traction forces generated by the wheels to the car frame.
- The "torque tube" transmits this force by directly coupling the axle differential to the transmission and therefore propels the car forward by pushing on the engine/transmission and then through the engine mounts to the car frame
- In contrast, the Hotchkiss drive has the traction forces transmitted to the car frame by using other suspension components such as leaf springs or trailing arms. A ball and socket type of joint called a "torque ball" is used at one end of the torque tube to allow relative motion between the axle and transmission due to suspension travel.
- Since the torque tube does not constrain the axle in the lateral (side-to-side) direction a pan hard rod is often used for this purpose.
- The combination of the pan hard rod and the torque tube allows the easy implementation of soft coil springs in the rear to give good ride quality.
- In addition to transmitting the traction forces, the torque tube is hollow and contains the rotating driveshaft. Inside the hollow torque ball is the universal joint of the driveshaft that allows relative motion between the two ends of the driveshaft. In most applications the drive shaft uses a single universal joint which has the disadvantage that it causes speed fluctuations in the driveshaft when the shaft is not straight.
- The Hotchkiss drive uses two universal joints which has the effect of canceling the speed fluctuations and gives a constant speed even when the shaft is no longer straight



5. **3. Discuss about the fluid flywheel with simple sketch .MAY/JUNE 2013**

- A fluid flywheel is a hydraulic device. In 1905 Dr.Hermannn Fottinger ,a chief engineer of the Vulcan werke AG in germany invented the flywheel. The fluid fly wheel is now a fundamental part of modern car design and is used in other applications including diesel locomotives.
- Fluid flywheel is a kind of fluid coupling in which the flywheel is the driving rotor. Fluid flywheel is a fluid device utilizing recirculated fluid with in a sealed housing to maintain speed or torque applied to a mechanical apparatus without relying on inertia of weight.
- A fluid flywheel consists of two concentric housings—a main circulation chamber and an angular recirculation chamber and an angular recirculation chamber surrounding the main circulation chamber. A shaft is mounted on the bearing of the outer housing and the extension of the shaft has a series of blades mounted there on.

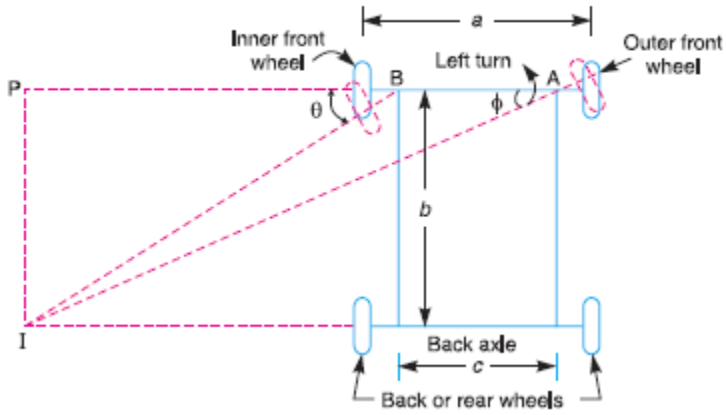


- Upon rotation of the shaft, fluid is drawn by the blades into the inlet end of the main circulation camber.
- The fluid is propelled from one series of blades to the next until it is discharged from the outlet end. The fluid is then redirected around the inner housing and re-circulated through the recirculation chamber. The fluid, being constantly re-circulated within the device will increase in speed or maintain the existing speed with relatively minimum force being applied to rotate the extending shaft. Toroidal shaped flow deflectors at opposing ends are useful for smooth transition of fluid from the main circulation chamber to the recirculation chamber and vice versa
- The driving unit is called impeller and the driven limit is called as runner. When the efficiency of the liquid coupling is highest, the impeller and the runner almost run at same speed. But usually the runner speed is less than the impeller. This speed lag of runner is called slip. The slip is greatest when the vehicle is at rest that is when the runner is stationary.
- Fluid coupling is used with conventional clutch and transmission to enable the driver to use clutch and gear with less skill and fatigue as compared to the mechanical linkage.

UNIT IV
STEERING, BRAKES AND SUSPENSION SYSTEMS

1. Explain briefly Ackermann steering mechanism with a neat sketch. (Dec'14, May'10, Dec 10)

Rack and pinion, recirculating ball, worm and sector



Rack and pinion steering mechanism:

1. Steering wheel;
2. Steering column;
3. Rack and pinion;
4. Tie rod;
5. Kingpin

- Rack and pinion unit mounted in the cockpit of an Ariel Atom sports car chassis. For most high volume production, this is usually mounted on the other side of this panel
- Steering box of a motor vehicle, the traditional (non-assisted), you may notice that the system allows you to adjust the braking and steering systems, you can also see the attachment system to the frame.
- Many modern cars use rack and pinion steering mechanisms, where the steering wheel turns the pinion gear; the pinion moves the rack, which is a linear gear that meshes with the pinion, converting circular motion into linear motion along the transverse axis of the car (side to side motion).
- This motion applies steering torque to the swivel pin ball joints that replaced previously used kingpins of the stub axle of the steered wheels via tie rods and a short lever arm called the steering arm.
- The rack and pinion design has the advantages of a large degree of feedback and direct steering "feel". A disadvantage is that it is not adjustable, so that when it does wear and develop lash, the only cure is replacement.

- The recirculating ball design also has a perceptible lash, or "dead spot" on center, where a minute turn of the steering wheel in either direction does not move the steering apparatus.

- This is easily adjustable via a screw on the end of the steering box to account for wear, but it cannot be entirely eliminated because it will create excessive internal forces at other positions and the mechanism will wear very rapidly. This design is still in use in trucks and other large vehicles, where rapidity of steering and direct feel are less important than robustness, maintainability, and mechanical advantage.

2. Describe the Anti-lock braking system (ABS). (Dec'15, May'11, Dec 09)

- Anti-lock braking system (ABS) is an automobile safety system that allows the wheels on a motor vehicle to maintain tractive contact with the road surface according to driver inputs while braking, preventing the wheels from locking up (ceasing rotation) and avoiding uncontrolled skidding.
- It is an automated system that uses the principles of threshold braking and cadence braking which were practiced by skillful drivers with previous generation braking systems. It does this at a much faster rate and with better control than a driver could manage.
- ABS generally offers improved vehicle control and decreases stopping distances on dry and slippery surfaces for many drivers; however, on loose surfaces like gravel or snow-covered pavement, ABS can significantly increase braking distance, although still improving vehicle control.
- Since initial widespread use in production cars, anti-lock braking systems have evolved considerably. Recent versions not only prevent wheel lock under braking, but also electronically control the front-to-rear brake bias.
- This function, depending on its specific capabilities and implementation, is known as electronic brake force distribution(EBD), traction control system, emergency brake assist, or electronic stability control(ESC).

Operation

- The anti-lock brake controller is also known as the CAB (Controller Anti-lock Brake).
- Typically ABS includes a central electronic control unit (ECU), four wheel speed sensors, and at least two hydraulic valves within the brake hydraulics. The ECU constantly monitors the rotational speed of each wheel
- if it detects a wheel rotating significantly slower than the others, a condition indicative of impending wheel lock, it actuates the valves to reduce hydraulic pressure to the brake at the affected wheel, thus reducing the braking force on that wheel; the wheel then turns faster.
- Conversely, if the ECU detects a wheel turning significantly faster than the others, brake hydraulic pressure to the wheel is increased so the braking force is reapplied, slowing down the wheel.
- This process is repeated continuously and can be detected by the driver via brake pedal pulsation. Some anti-lock systems can apply or release braking pressure 15 times per second. Because of this, the wheels of cars equipped with ABS are practically impossible to lock even during panic braking in extreme conditions.
- Modern ABS applies individual brake pressure to all four wheels through a control system of hub-mounted sensors and a dedicated micro-controller. ABS is offered or comes standard on most road vehicles produced today and is the foundation for electronic stability control systems, which are rapidly increasing in popularity due to the vast reduction in price of vehicle electronics over the years.
- ABS equipment may also be used to implement a traction control system (TCS) on acceleration of the vehicle.
- If, when accelerating, the tire loses traction, the ABS controller can detect the situation and take suitable action so that traction is regained. More sophisticated versions of this can also control throttle levels and brakes simultaneously.

Components of ABS

There are four main components of ABS:

- Speed sensors,
- Valves,
- Pump, and
- Controller.

Speed sensors

- A speed sensor is used to determine the acceleration or deceleration of the wheel. These sensors use a magnet and a coil of wire to generate a signal. The rotation of the wheel or differential induces a magnetic field around the sensor.
- The fluctuations of this magnetic field generate a voltage in the sensor. Since the voltage induced in the sensor is a result of the rotating wheel, this sensor can become inaccurate at slow speeds.
- The slower rotation of the wheel can cause inaccurate fluctuations in the magnetic field and thus cause inaccurate readings to the controller

Valves

- There is a valve in the brake line of each brake controlled by the ABS. On some systems, the valve has three positions
- In position one, the valve is open; pressure from the master cylinder is passed right through to the brake
- In position two, the valve blocks the line, isolating that brake from the master cylinder. This prevents the pressure from rising further should the driver push the brake pedal harder.

Pump

- The pump in the ABS is used to restore the pressure to the hydraulic brakes after the valves have released it. A signal from the controller will release the valve at the detection of wheel slip.
- After a valve release the pressure supplied from the user, the pump is used to restore a desired amount of pressure to the braking system. The controller will modulate the pumps status in order to provide the desired amount of pressure and reduce slipping.

Controller

- The controller is an ECU type unit in the car which receives information from each individual wheel speed sensor, in turn if a wheel loses traction the signal is sent to the controller, the controller will then limit the brake force (EBD) and activate the ABS modulator which actuates the braking valves on and off.

Use

- The ABS controller knows that such a rapid deceleration is impossible, so it reduces the pressure to that brake until it sees an acceleration, then it increases the pressure until it sees the deceleration again. It can do this very quickly, before the tire can actually significantly change speed.
- The result is that the tire slows down at the same rate as the car, with the brakes keeping the tires very near the point at which they will start to lock up. This gives the system maximum braking power.
- When the ABS is in operation the driver will feel a pulsing in the brake pedal; this comes from the rapid opening and closing of the valves. This pulsing also tells the driver that the ABS has been triggered. Some ABS systems can cycle up to 16 times per second.

3. Describe the Hydraulic braking system(Dec'11, May'08, Dec 07)

- The disc brake or disk brake is a device for slowing or stopping the rotation of a wheel while it is in motion. A brake disc (or rotor in U.S. English) is usually made of cast iron, but may in some cases be made of composites such as reinforced carbon-carbon or ceramic-matrix composites.
- This is connected to the wheel and/or the axle. To stop the wheel, friction material in the form of brake pads (mounted on a device called a brake caliper) is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc. Friction causes
- The disc and attached wheel to slow or stop. Brakes (both disc and drum) convert motion to heat, but if the brakes get too hot, they will become less effective because they cannot dissipate enough heat. This condition of failure is known as brake fade.

Construction of Braking system

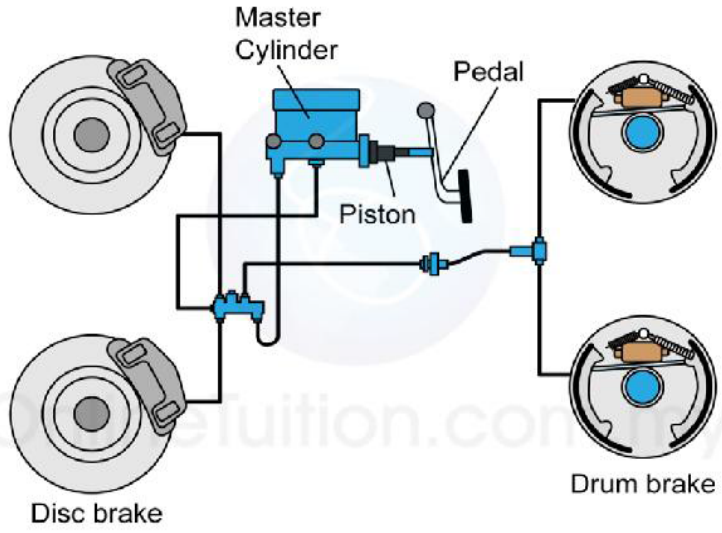
The most common arrangement of hydraulic brakes for passenger vehicles, motorcycles, scooters, and mopeds, consists of the following:

- Brake pedal or lever
- A pushrod (also called an actuating rod)
- A master cylinder assembly containing a piston assembly
- Reinforced hydraulic lines

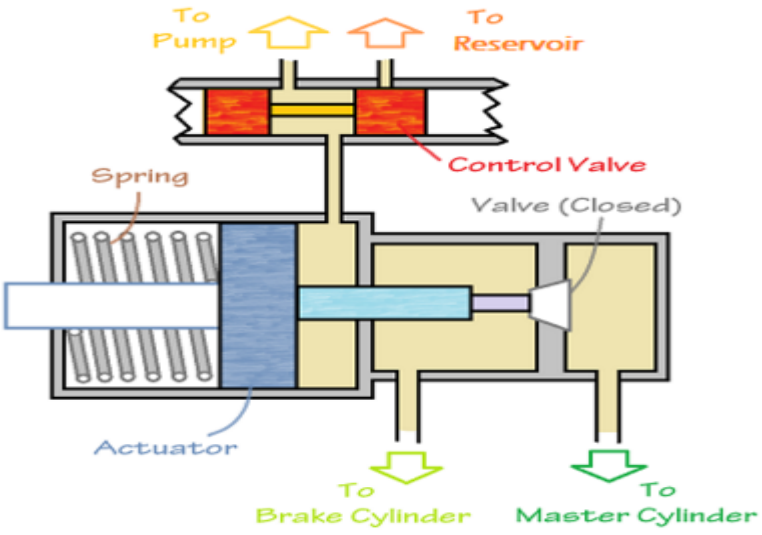
- Brake caliper assembly usually consisting of one or two hollow aluminum or chrome-plated steel pistons (called caliper pistons), a set of thermally conductive brake pads and a rotor (also called a brake disc) or drum attached to an axle.The system is usually filled with a glycol-ether based brake fluid (other fluids may also be used).
- At one time, passenger vehicles commonly employed drum brakes on all four wheels. Later, disc brakes were used for the front and drum brakes for the rear.
- However disc brakes have shown better heat dissipation and greater resistance to 'fading' and are therefore generally safer than drum brakes.
- So four-wheel disc brakes have become increasingly popular, replacing drums on all but the most basic vehicles.
- Many two-wheel vehicle designs, however, continue to employ a drum brake for the rear wheel. The following description uses the terminology for and configuration of a simple
- In a hydraulic brake system, when the brake pedal is pressed, a pushrod exerts force on the piston(s) in the master cylinder, causing fluid from the brake fluid reservoir to flow into a pressure chamber through a compensating port.
- This results in an increase in the pressure of the entire hydraulic system, forcing fluid through the hydraulic lines toward one or more calipers where it acts upon one or two caliper pistons sealed by one or more seated O-rings (which prevent leakage of the fluid).

- The brake caliper pistons then apply force to the brake pads, pushing them against the spinning rotor, and the friction between the pads and the rotor causes a braking torque to be generated, slowing the vehicle.
- Heat generated by this friction is either dissipated through vents and channels in the rotor or is conducted through the pads.
- Subsequent release of the brake pedal/lever allows the spring(s) in my master cylinder assembly to return the master piston(s) back into position.

- This action first relieves the hydraulic pressure on the caliper, then applies suction to the brake piston in the caliper assembly, moving it back into its housing and allowing the brake pads to release the rotor.
- The hydraulic braking system is designed as a closed system: unless there is a leak in the system, none of the brake fluid enters or leaves it, nor does the fluid get consumed through use.
- With a neat sketch explain the function of a master cylinder in hydraulic brakes. In a hydraulic brake system,
- when the brake pedal is pressed, a pushrod exerts force on the piston(s) in the master cylinder, causing fluid from the brake fluid reservoir to flow into a pressure chamber through a compensating port.
- This results in an increase in the pressure of the entire hydraulic system, forcing fluid through the hydraulic lines toward one or more calipers where it acts upon one or two caliper pistons sealed by one or more seated O-rings (which prevent leakage of the fluid).
- The brake caliper pistons then apply force to the brake pads, pushing them against the spinning rotor, and the friction between the pads and the rotor causes a braking torque to be generated, slowing the vehicle.
- Heat generated by this friction is either dissipated through vents and channels in the rotor or is conducted through the pads, which are made of specialized heat-tolerant materials such as kevlar orsintered glass.



- Subsequent release of the brake pedal/lever allows the spring(s) in the master cylinder assembly to return the master piston(s) back into position.



- This action first relieves the hydraulic pressure on the caliper, then applies suction to the brake piston in the caliper assembly, moving it back into its housing and allowing the brake pads to release the rotor.

4. Discuss the working of suspension system used in cars(Dec'11, May'10, Dec 07)

Suspension system is the term given to the system of springs, shock absorbers and linkages that connects a vehicle to its wheels. It is basically cushion for passengers protects the luggage or any cargo and also itself from damage and wear.

The main roles of suspension system are as follows:

- It supports the weight of vehicle.
- Provides smoother ride for the driver and passengers i.e. acts as cushion.
- Protects your vehicle from damage and wear .
- It also plays a critical role in maintaining self driving conditions.
- It also keeps the wheels pressed firmly to the ground for traction .
- It isolates the body from road shocks and vibrations which would otherwise be transferred to the passengers and load.

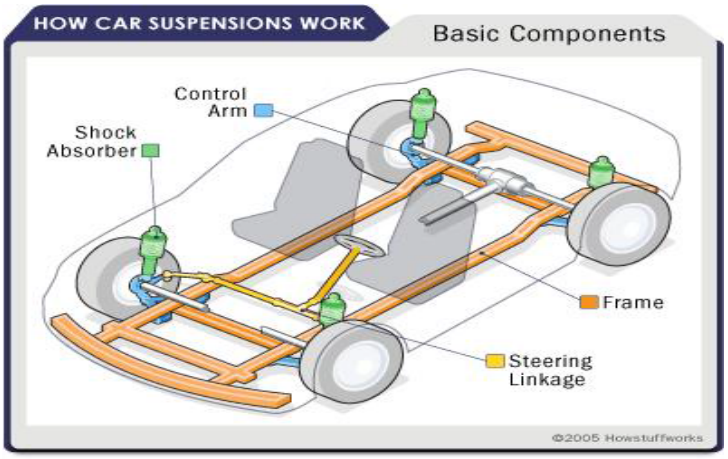
Principle :

When a tire hits an obstruction, there is a reaction force. The size of this reaction force depends on the unsprung mass at each wheel assembly. In general, the larger the ratio of sprung weight to unsprung weight, the less the body and vehicle occupants are affected by bumps, dips, and other surface imperfections such as small bridges. A large sprung weight to unsprung weight ratio can also impact vehicle control. No road is perfectly flat i.e. without irregularities. Even a freshly paved highways have subtle imperfections that can be interact with vehicle's wheels. These are the imperfections that apply forces on wheels.

According to **Newton 's law of motion** all forces have both magnitude and direction. A bump in the road causes the wheel to move up and down perpendicular to the road surface. The magnitude of course ,depends on whether the wheel is striking a giant bump or a tiny speck. Thus, either the wheel experiences a vertical acceleration as it passes over an imperfection. The suspension of a car is actually part of the chassis, which comprises all of the important systems located beneath the car's body.

These system include:

- Frame
- Suspension system
- Steering system
- Tires or Wheels

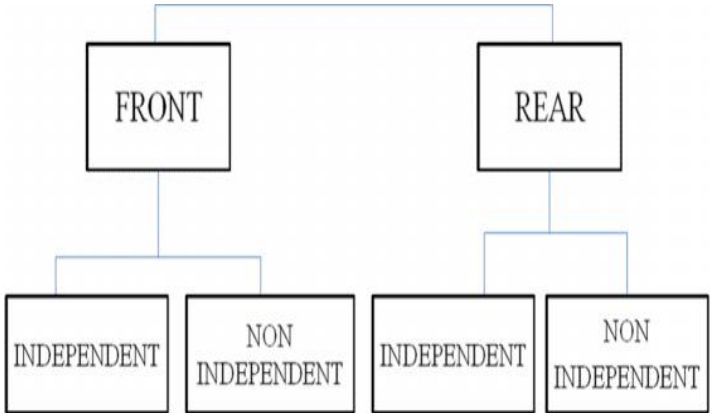


Components of Suspension system

There are three fundamental components of any suspension system .

- Springs
  - Coil spring
  - Leaf springs
  - Air springs
- Dampers
  - Shock Absorbers
  - Struts:-
  - Anti-sway Bars
- Anti sway bars.

Types of Suspension system



Advantages

- Comfort to passengers
- Good handling
- Shields the vehicle from damage
- Increases life of vehicle
- Keeps the tires pressed firmly to ground.

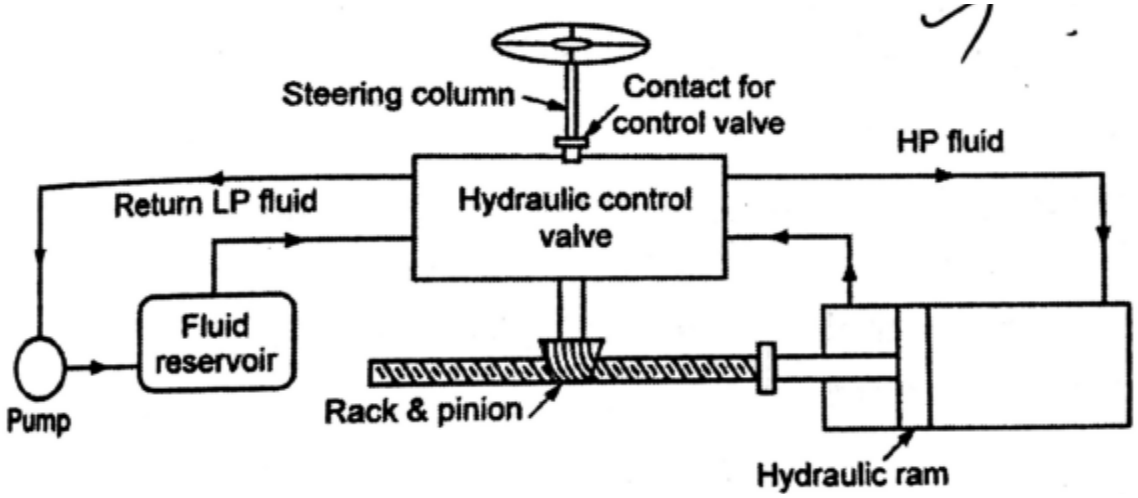
5. Discuss about the power assisted steering (PAS) (Dec'12, May'11, Dec 09)

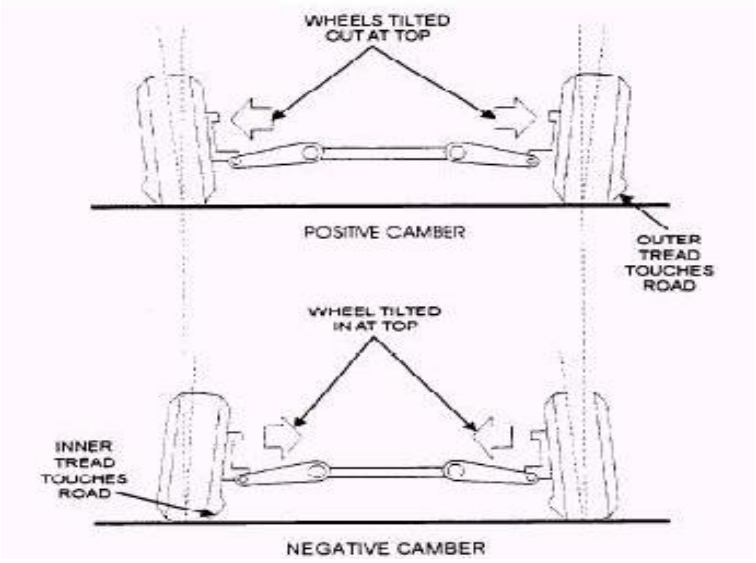
- In automobiles, power steering (also known as power assisted steering (PAS) or steering assist system) helps drivers steer by augmenting steering effort of the steering wheel.
- Hydraulic or electric actuators add controlled energy to the steering mechanism, so the driver needs to provide only modest effort regardless of conditions.

- Power steering helps considerably when a vehicle is stopped or moving slowly. Also, power steering provides some feedback of forces acting on the front wheels to give an ongoing sense of how the wheels are interacting with the road.
- This is typically called "road feel". Representative power steering systems for cars augment steering effort via an actuator, a hydraulic cylinder, which is part of a servo system. These systems have a direct mechanical connection between the steering wheel and the linkage that steers the wheels.
- This means that power-steering system failure (to augment effort) still permits the vehicle to be steered using manual effort alone.
- Other power steering systems (such as those in the largest off-road construction vehicles) have no direct mechanical connection to the steering linkage; they require power. Systems of this kind, with no mechanical connection, are sometimes called "drive by wire" or "steer by wire", by analogy with aviation's "fly-by-wire".
- In this context, "wire" refers to electrical cables that carry power and data, not thin-wire-rope mechanical control cables.
- In other power steering systems, electric motors provide the assistance instead of hydraulic systems. As with hydraulic types, power to the actuator (motor, in this case) is controlled by the rest of the power-steering system.
- Some construction vehicles have a two-part frame with a rugged hinge in the middle; this hinge allows the front and rear axles to become non-parallel to steer the vehicle. Opposing hydraulic cylinders move the halves of the frame relative to each other to steer.
- Power steering helps the driver of a vehicle to steer by directing some of the power to assist in swiveling the steered road wheels about their steering axes. As vehicles have become heavier and switched to front wheel drive, particularly using negative offset geometry, along with increases in tire width and diameter, the effort needed to turn the wheels about their steering axis has increased, often to the point where major physical exertion would be needed were it not for power assistance.
- To alleviate this auto makers have developed power steering systems: or more correctly power-assisted steering—on road going vehicles there has to be a mechanical linkage as a failsafe.
- There are two types of power steering systems hydraulic and electric/electronic. A hydraulic electric hybrid system is also possible. A hydraulic power steering (HPS) uses hydraulic pressure supplied by an engine-driven pump to assist the motion of turning the steering wheel.
- Electric power steering (EPS) is more efficient than the hydraulic power steering, since the electric power steering motor only needs to provide assistance when the steering wheel is turned, whereas the hydraulic pump must run constantly.

Speed Sensitive Steering

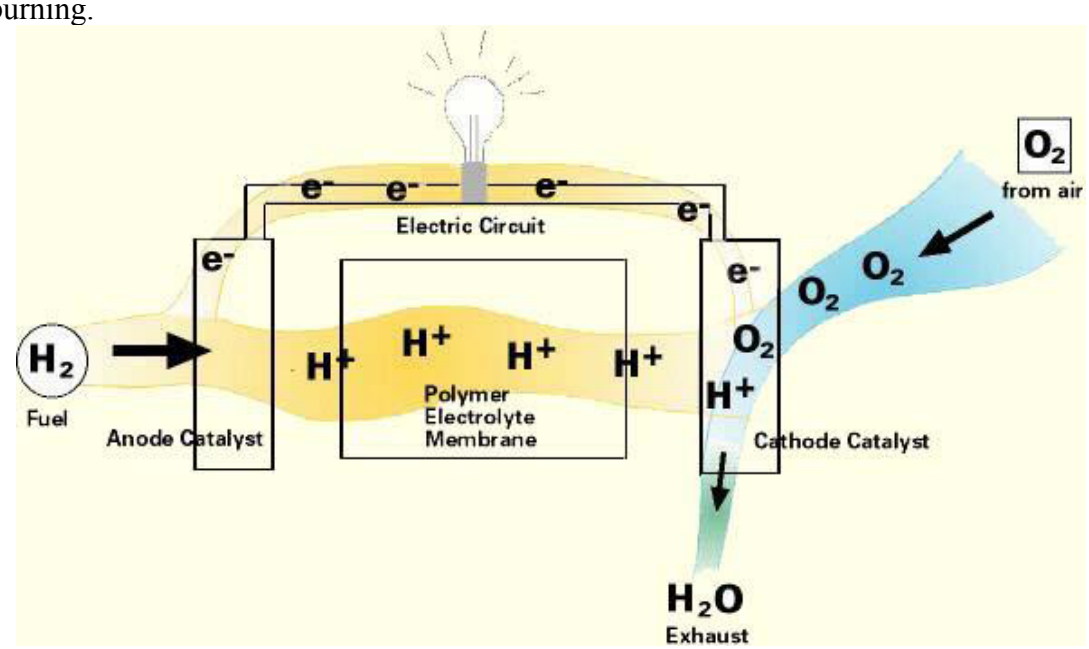
- An outgrowth of power steering is speed sensitive steering, where the steering is heavily assisted at low speed and lightly assisted at high speed.
- The auto makers perceive that motorists might need to make large steering inputs while maneuvering for parking, but not while traveling at high speed.
- The first vehicle with this feature was the Citroën SM with its Diravi layout[citation needed], although rather than altering the amount of assistance as in modern power steering systems, it altered the pressure on a centring cam which made the steering wheel try to "spring" back to the straight-ahead position.
- Modern speed-sensitive power steering systems reduce the mechanical or electrical assistance as the vehicle speed increases, giving a more direct feel. This feature is gradually becoming more common.


Steering column
Contact for control valve
HP fluid
Return LP fluid
Hydraulic control valve
Fluid reservoir
Pump
Rack & pinion
Hydraulic ram


WHEELS TILTED OUT AT TOP
POSITIVE CAMBER
OUTER TREAD TOUCHES ROAD
WHEEL TILTED IN AT TOP
INNER TREAD TOUCHES ROAD
NEGATIVE CAMBER

UNIT- 5
ALTERNATIVE ENERGY SOURCES

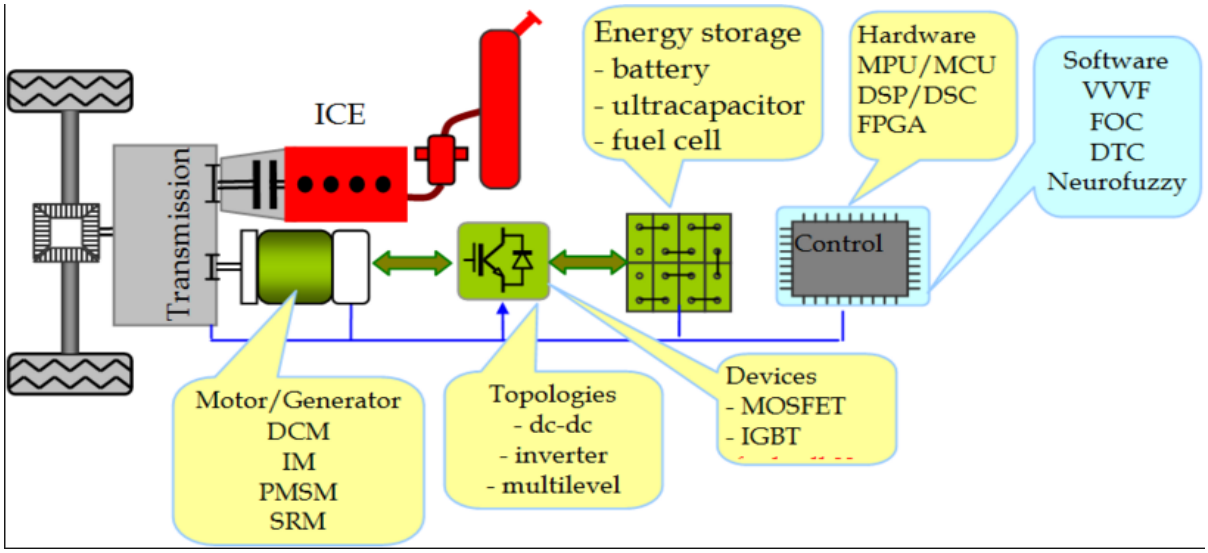
1. **With simple sketch explain the construction and working principle of fuel cell. (Dec'14, May'10)**
   - A Fuel Cell is an electrochemical device that combines hydrogen and oxygen to produce
   - electricity, with water and heat as its by-product. Since conversion of the fuel to energy takes place via an electrochemical process, not combustion.
   - It is a clean, quiet and highly efficient process- two to three times more efficient than fuel burning.



   - It operates similarly to a battery, but it does not run down nor does it require recharging As long as fuel is supplied, a Fuel Cell will produce both energy and heat A Fuel Cell consists of two catalyst coated electrodes surrounding an electrolyte.
   - One electrode is an anode and the other is cathode The process begins when Hydrogen molecules enter the anode The catalyst coating separates hydrogen's negatively charged electrons from the positively charged protons The electrolyte allows the protons to pass through to the cathode, but not the electrons. Instead the electrons are directed through an external circuit which creates electrical current.
   - While the electrons pass through the external circuit, oxygen molecules pass through the cathode. There the oxygen and the protons combine with the electrons after they have passed through the external circuit.
   - When the oxygen and the protons combine with the electrons it produces water and heat. Individual fuel cells can then be placed in a series to form a fuel cell stack. The stack can be used in a system to power a vehicle or to provide stationary power to a building

2. **Discuss the concept of electric and hybrid vehicle with neat sketch. (Dec'12, May'10, Dec 07)**
   - A hybrid electric vehicle (HEV) is a type of hybrid vehicle and electric vehicle which combines a conventional internal combustion engine (ICE) propulsion system with an electric propulsion system. The presence of the electric power train is intended to achieve either better fuel economy than a conventional vehicle or better performance.
   - There are a variety of HEV types, and the degree to which they function as EVs varies as well. The most common form of HEV is the hybrid electric car, although hybrid electric trucks (pickups and tractors) and buses also exist.

- Modern HEVs make use of efficiency-improving technologies such as regenerative braking, which converts the vehicle's kinetic energy into electric energy to charge the battery, rather than wasting it as heat energy as conventional brakes do. Some varieties of HEVs use their internal combustion engine to generate electricity by spinning an electrical generator (this combination is known as a motor-generator), to either recharge their batteries or to directly power the electric drive motors.
- Many HEVs reduce idle emissions by shutting down the ICE at idle and restarting it when Needed this is known as a start-stop system.



- A hybrid-electric produces less emission from its ICE than a comparably sized gasoline car, since an HEV's gasoline engine is usually smaller than a comparably sized pure gasoline-burning vehicle (natural gas and propane fuels produce lower emissions) and if not used to directly drive the car, can be geared to run at maximum efficiency, further improving fuel economy.

3. **Discuss the use of following alternative fuels in automobile engines (i)LPG,(ii)Biodiesel,(iii)CNG**
(Dec'13, May'09, Dec 07)

(i)Liquefied petroleum gas as a Fuel in Automobile;

- Liquefied petroleum gas or liquid petroleum gas (LPG or LP gas), also referred to as simply propane or butane, is a flammable mixture of hydrocarbon gases used as a fuel in heating appliances, cooking equipment, and vehicles.
- It is increasingly used as an aerosol propellant and a refrigerant, replacing chlorofluorocarbons in an effort to reduce damage to the ozone layer. When specifically used as a vehicle fuel it is often referred to as auto gas.
- Varieties of LPG bought and sold include mixes that are primarily propane (C_3H_8),primarily butane (C_4H_{10}) and, most commonly, mixes including both propane and butane. In winter, the mixes contain more propane, while in summer, they contain more butane.
- LPG is prepared by refining petroleum or "wet" natural gas, and is almost entirely derived from fossil fuel sources, being manufactured during the refining of petroleum (crude oil), or extracted from petroleum or natural gas streams as they emerge from the ground.
- Itcurrently provides about 3% of all energy consumed, and burns relatively cleanly with no soot and very few sulfur emissions.As it is a gas, it does not pose ground or water pollution hazards, but it can cause airpollution.
- LPG has a typical specific calorific value of 46.1 MJ/kg compared with 42.5 MJ/kg for fuel oil and 43.5 MJ/kg for premium grade petrol (gasoline).[6] However, its energy density

per volume unit of 26 MJ/L is lower than either that of petrol or fuel oil, as its relative density is lower (about 0.5–0.58, compared to 0.71–0.77 for gasoline).

- As its boiling point is below room temperature, LPG will evaporate quickly at normal temperatures and pressures and is usually supplied in pressurised steel vessels. They are typically filled to 80–85% of their capacity to allow for thermal expansion of the contained liquid.
- The ratio between the volumes of the vaporized gas and the liquefied gas varies depending on composition, pressure, and temperature, but is typically around 250:1. The pressure at which LPG becomes liquid, called its vapour pressure, likewise varies depending on composition and temperature; for example, it is approximately 220 kilopascals (32 psi) for pure butane at 20 °C (68 °F), and approximately 2,200 kilopascals (320 psi) for pure propane at 55 °C (131 °F). LPG is heavier than air, unlike natural gas, and thus will flow along floors and tend to settle in low spots, such as basements.
- There are two main dangers from this. The first is a possible explosion if the mixture of LPG and air is within the explosive limits and there is an ignition source. The second is suffocation due to LPG displacing air, causing a decrease in oxygen concentration. Large amounts of LPG can be stored in bulk cylinders and can be buried underground.

(ii)Bio diesel as a Fuel in Automobile;

- Biodiesel and conventional diesel vehicles are one in the same. Although light-, medium and heavy-duty diesel vehicles are not technically "alternative fuel" vehicles, many are capable of running on biodiesel. Biodiesel, which is most often used as a blend with regular diesel fuel, can be used in many diesel vehicles without any engine modification.
- The most common biodiesel blend isB20, which is 20% biodiesel and 80% conventional diesel. B5 (5% biodiesel, 95% diesel) is also commonly used in fleets.Before using biodiesel, be sure to check your engine warranty to ensure that higher-levelblends (all OEMs accept the use of B5 and many accept the use of B20) of this alternative fuel don'tvoid or affect it.
- High-level biodiesel blends (blends over B20) can have asolvency effect in enginesand fuel systems that previously used petroleum diesel which may result in degraded seals and clogged fuel filters.
- Biodiesel improves fuel lubricity and raises the cetane number of the fuel. Diesel engines depend on the lubricity of the fuel to keep moving parts from wearing prematurely.
- Federal regulations have gradually reduced allowable fuel sulfur to only 15 parts per million, which has often resulted in lowered aromatics content in diesel fuel. One advantage of biodiesel is that it can impart adequate lubricity to diesel fuels at blend levels as low as 1%.

(iii)Natural Gas as a Fuel in Automobile;

- CNG may also be mixed with biogas, produced from landfills or wastewater, which doesn't increase the concentration of carbon in the atmosphere.
- Despite its advantages, the use of natural gas vehicles faces several limitations, including fuel storage and infrastructure available for delivery and distribution at fueling stations.
- CNG must be stored in high pressure cylinders (3000psi to 3600psi operation pressure), and LNG must be stored in cryogenic cylinders (-260F to -200F).
- These cylinders take up more space than gasoline or diesel tanks that can be molded in intricate shapes to store more fuel and use less on-vehicle space.
- CNG tanks are usually located in the vehicle's trunk or pickup bed, reducing the space available for other cargo. This problem can be solved by installing the tanks under the body of the vehicle, or on the roof (typical for busses), leaving cargo areas free.
- As with other alternative fuels, other barriers for widespread use of NGVs are natural gas distribution to and at fueling stations as well as the low number of CNG and LNG stations. CNG powered vehicles are considered to be safer than gasoline-powered vehicles

4. **Explain the method of biodiesel production through transesterification process**
(Dec'11, May'13)

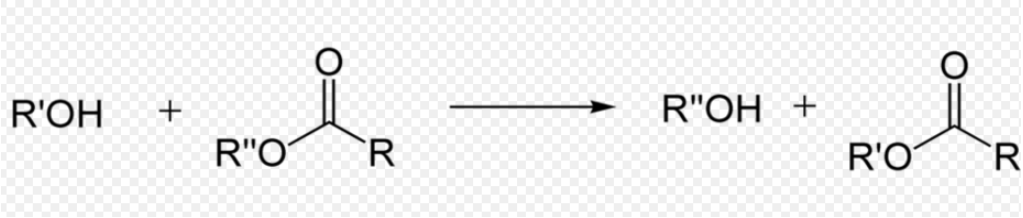
- Animal and plant fats and oils are composed of triglycerides, which are esters formed by the reactions of three free fatty acids and the trihydric alcohol, glycerol. In the transesterification process, the added alcohol (commonly, methanol orethanol) is deprotonated with a base to make it a stronger nucleophile.
- As can be seen, the reaction has no other inputs than the triglyceride and the alcohol. Under normal conditions, this reaction will proceed either exceedingly slowly or not at all, so heat, as well as catalysts (acid and/or base) are used to speed the reaction.
- It is important to note that the acid or base are not consumed by the transesterification reaction, thus they are not reactants, but catalysts. Common catalysts for transesterification include sodium hydroxide, potassium hydroxide, and sodium methoxide.
- Almost all biodiesel is produced from virgin vegetable oils using the base-catalyzed technique as it is the most economical process for treating virgin vegetable oils, requiring only low temperatures and pressures and producing over 98% conversion yield (provided the starting oil is low in moisture and free fatty acids).
- However, biodiesel produced from other sources or by other methods may require acid catalysis, which is much slower. Since it is the predominant method for commercial-scale production, only the base-catalyzed transesterification process will be described below.

Triglycerides

(**1**) are reacted with an alcohol such as ethanol

(**2**) to give ethyl esters of fatty acids

(**3**) and glycerol



Transesterification: alcohol + ester → different alcohol + different ester

- The alcohol reacts with the fatty acids to form the mono-alkyl ester (biodiesel) and crude glycerol. The reaction between the biolipid (fat or oil) and the alcohol is a reversible reaction so excess alcohol must be added to ensure complete conversion.

5. **Explain the working of hydrogen in automobile. (Dec'12, May'11)**
- Hydrogen is the simplest and the most abundant element in the universe. Even though it's simple and there's so much of it, hydrogen does not occur naturally as a gas on the earth

it's always combined with other things. Hydrogen is high in energy, yet an engine that burns pure hydrogen produces almost no pollution.

- A hydrogen car is an automobile which uses hydrogen as its primary source of power for locomotion. These cars generally use the hydrogen in one of two methods: combustion or fuel-cell conversion. In combustion, the hydrogen is "burned" in engines in fundamentally the same method as traditional gasoline cars.
- In fuel-cell conversion, the hydrogen is turned into electricity through fuel cells which then powers electric motors. With either method, the only byproduct from the spent hydrogen is water, however during combustion with air NOx can be produced
- Hydrogen technologies are technologies that relate to the production and use of hydrogen. **Hydrogen technologies** are applicable for many uses.
- Some hydrogen technologies are carbon neutral and could have a role in preventing climate change and a possible future hydrogen economy. Hydrogen is a widely used chemical used in various applications including ammonia production, oil refining and energy.[1] Hydrogen is not a primary energy source, because it is not naturally occurring as a fuel.
- It is, however widely regarded as an ideal energy storage medium, due to the ease with which electric power can convert water into its hydrogen and oxygen components through electrolysis and can be converted back to electrical power using a fuel cell.
- **Hydrogen** is a chemical element with chemical symbol **H** and atomic number 1. With an atomic weight of 1.00794 u, hydrogen is the lightest element on the periodic table. Its monatomic form (H) is the most abundant chemical substance in the Universe, constituting roughly 75% of all baryonicmass.
- Non-remnant stars are mainly composed of hydrogen in i plasma state. The most common isotope of hydrogen, termed *protium* has one proton and no neutrons.
- The universal emergence of atomic hydrogen first occurred during there combination epoch. At standard temperature and pressure, hydrogen is acolorless, odorless, tasteless, non-toxic, nonmetallic, highly combustiblediatomic gas with the molecular formula H_2. Since hydrogen readily formscovalent compounds with most non-metallic elements, most of the hydrogen on Earth exists in molecular forms such as in the form of water or organic compounds.
- Hydrogen plays a particularly important role in acid–base reactions as many acid-base reactions involve the exchange of protons between soluble molecules. In ionic compounds, hydrogen can take the form of a negative charge (i.e., anion)
- The hydrogen cation is written as though composed of a bare proton, but in reality, hydrogen cations in ionic compounds are always more complex species than that would suggest..

Advantages of hydrogen energy

- Hydrogen comes from water by splitting it into oxygen and hydrogen, so supplies are almost limitless.
- As hydrogen is a diatomic molecule, the product of combustion is only water. Therefore, it does not produce the harmful gasses that gasoline and diesel cars produce, such as carbon dioxide.
- Hydrogen itself is not poisonous. Therefore, in case of outflow, hydrogen is safer than any other gas.

Disadvantages of hydrogen energy

- It’s hard to store the large amount that is required to fuel a car
- Hydrogen is often taken from unrenewable resources, like fossil fuels.