Questions and Answers in

Mechanical Engineering Part One

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Question One

What are Mechanical Properties of Material which every Mechanical Engineer Should Know?

Mechanical properties of material:

There are mainly two types of materials. First one is metal and other one is nonmetals. Metals are classified into two types: Ferrous metals and Non-ferrous metals. Ferrous metals mainly consist iron with comparatively small addition of other materials. It includes iron and its alloy such as cast iron, steel, HSS etc. Ferrous metals are widely used in mechanical industries for its various advantages.

Nonferrous metals contain little or no iron. It includes aluminum, magnesium, copper, zinc etc.

Most Mechanical Properties are associated with metals these are-

#1. Strength:

The ability of material to withstand load without failure is known as strength. If a material can bear more load, it means it has more strength. Strength of any material mainly depends on type of loading and deformation before fracture. According to loading types, strength can be classified into three types.

1. Tensile strength:
2. Compressive strength:
3. Shear strength:

According to the deformation before fracture, strength can be classified into three types.

1. Elastic strength:
2. Yield strength:
3. Ultimate strength:

#2. Homogeneity:

If a material has same properties throughout its geometry, known as homogeneous material and the property is known as homogeneity. It is an ideal situation but practically no material is homogeneous.

#3. Isotropy:

A material which has same elastic properties along its all loading direction known as isotropic material.

#4. Anisotropy:

A material which exhibits different elastic properties in different loading direction known as an-isotropic material.

#5. Elasticity:

If a material regains its original dimension after removal of load, it is known as elastic material and the property by virtue of which it regains its original shape is known as elasticity.

Every material possesses some elasticity. It is measure as the ratio of stress to strain under elastic limit.

#6. Plasticity:

The ability of material to undergo some degree of permanent deformation without failure after removal of load is known as plasticity. This property is used for shaping material by **metal working**. It is mainly depending on temperature and elastic strength of material.

#7. Ductility:

Ductility is a property by virtue of which metal can be drawn into wires. It can also define as a property which permits permanent deformation before fracture under tensile loading. The amount of permanent deformation (measure in percentage elongation) decides either the material is ductile or not.

Percentage elongation = (Final Gauge Length – Original Gauge Length) *100/ Original Gauge Length

If the percentage elongation is greater than 5% in a gauge length 50 mm, the material is ductile and if it less than 5% it is not.

#8. Brittleness:

Brittleness is a property by virtue of which, a material will fail under loading without significant change in dimension. Glass and **cast iron** are well known brittle materials.

#9. Stiffness:

The ability of material to resist elastic deformation or deflection during loading, known as stiffness. A material which offers small change in dimension during loading is stiffer. For example, steel is stiffer than aluminum.

#10. Hardness:

The property of a material to resist penetration is known as hardness. It is an ability to resist scratching, abrasion or cutting. It is also define as an ability to resist fracture under point loading.

#11. Toughness:

Toughness is defined as an ability to withstand with plastic or elastic deformation without failure. It is defined as the amount of energy absorbed before actual fracture.

#12. Malleability:

A property by virtue of which a metal can flatten into thin sheets, known as malleability. It is also defined as a property which permits plastic deformation under compression loading.

#13. Machinability:

A property by virtue of which a material can be cut easily.

#14. Damping:

The ability of metal to dissipate the energy of vibration or cyclic stress is called damping. Cast iron has good damping property, that's why most of machines body made by cast iron.

#15. Creep:

The slow and progressive change in dimension of a material under influence of its safe working stress for long time is known as creep. Creep is mainly depending on time and temperature. The maximum amount of stress under which a material withstand during infinite time is known as creep strength.

#16. Resilience:

The amount of energy absorb under elastic limit during loading is called resilience. The maximum amount of the energy absorb under elastic limit is called proof resilience.

#17. Fatigue Strength:

The failure of a work piece under cyclic load or repeated load below its ultimate limit is known as fatigue. The maximum amount of cyclic load which a work piece can bear for infinite number of cycle is called fatigue strength. Fatigue strength is also depending on work piece shape, geometry, surface finish etc.

#18. Embrittlement:

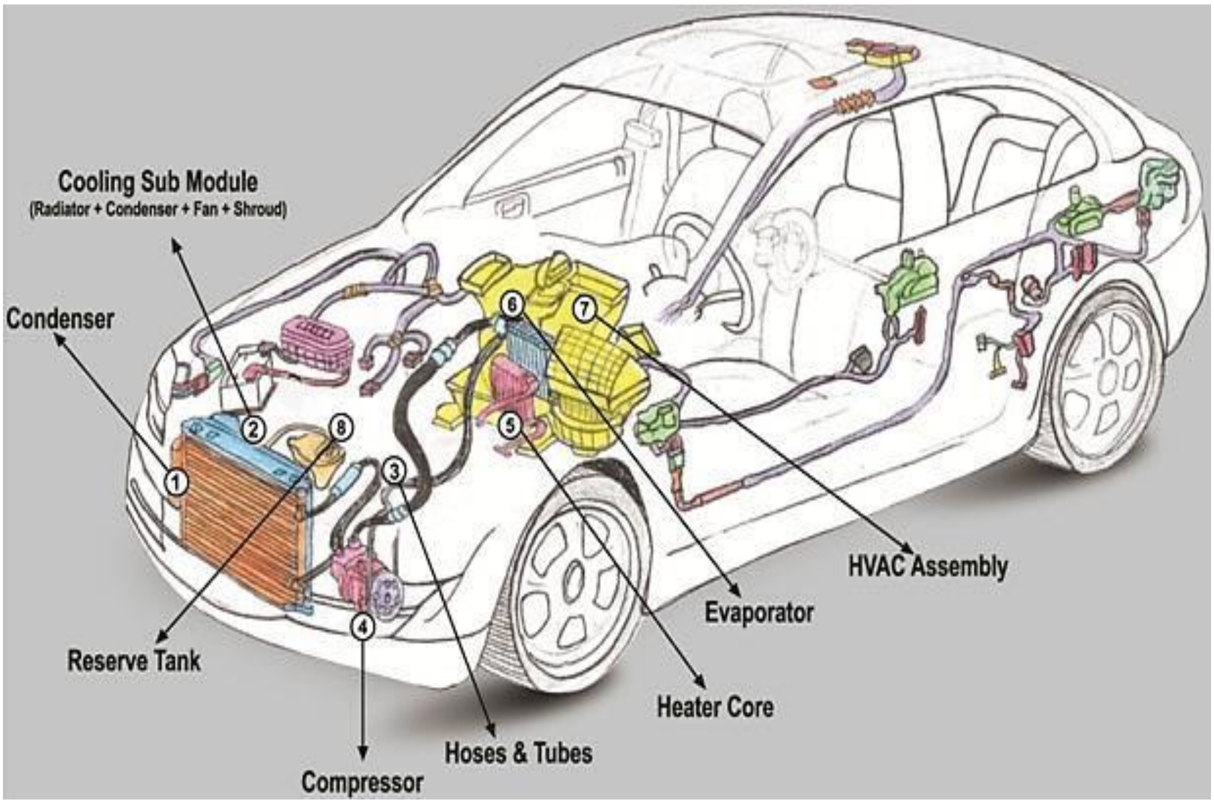
The loss of ductility of a metal caused by physical or chemical changes, which make it brittle, is called embrittlement.

Question Two

Define Automotive air conditioning and it's working principles?

Nowadays, the cars and trucks we buy all come with the feature of air conditioning. The automotive air conditioning system works on the ideology of the reverse Brayton or the Rankine cycle. This system effectively controls the temperature and the humidity of the atmospheric air and circulates it in the vehicle cabin.

The automotive air conditioning system contains refrigeration, air circulation and distribution and the controlling system. Here, the refrigeration helps in cooling of the air with the help of the parts like compressor, condenser etc. The air circulating system effectively distributes the cold air through a blower or the air duct. The control system senses the temperature and allows managing the refrigerating system.



Essential parts of automotive air conditioning system

An automotive air conditioning system works with the incorporation of parts like

- Condenser
- Compressor
- Evaporator
- Receiver-dehydrator
- Connecting lines including,
- Orifice tube
- Expansion valve
- Absolute valve
- Suction throttle valve
- Evaporation pressure regulator valve
- Thermal sensors
- High pressure cut off switch
- Cycling compressor switch
- Refrigerants (Nowadays, Freon 12 is replaced by the alternative refrigerant R134a)

Watch the video on next page to understand the working of the automotive air conditioning system-

The working of the automotive air conditioning system is the same as the normal air conditioners. The compressor suppresses the refrigerant vapours at very high pressure coming from the evaporator. The car engine drives the compressor with the belt drive. Hence, the magnetic clutch is responsible for engaging and disengaging the compressor.

There is a notable increase in the refrigerant pressure and temperature in the compressor, as a result turns it into vapours. The compressor discharges the high-pressure vapours to the condenser. It much as works like a heat-exchanger and is in front the vehicle. In conclusion, the refrigerant releases the heat and converts it to the liquid form. Because of ram air and the electric driven fan, the temperature of the refrigerant cools down.

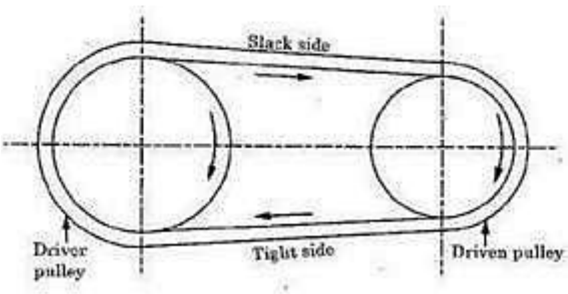
The refrigerant at very high pressure moves from the dehydrator and extracts moisture. After extracting moisture, it passes through the expansion valves and expands the refrigerant at low pressure. In result, the expansion process cools down the evaporator. The sensing device also known as the temperature sensing tubes, signals the diaphragm at the expansion valve and it varies the orifice sizing. This entirely depends on the temperature of the evaporator outlet, as a result, helps in automatic temperature control. Most noteworthy, the evaporator is of the similar construction as the condenser.

Question Three

What is Belt Drive and its Types?

Belt Drives are a type of frictional drives used for transmitting powers. They are quite popular owing to their high durability and reliability. For most of the power transmission requirements, belt drives are also economical and financially viable. They are comparatively easy to install and maintain and generally are durable and viable in the long run.

Belt drives are used to transmit power between two shafts which do not have a common axis. The amount of power transmitted between the shafts is dependent upon the amount of friction between the two. Factors that determine the power transmission are the velocity of the belt, belt tension between the pulleys and the angle of contact between the pulleys.



For getting the optimal performance and the desired results from the belt drive the selection of the right belt according to the application becomes crucial. Selection of the right kind of belt for a given application will depend upon the type of drive used, operating RPM, Horsepower generation, Diameter of pulleys and center distance, take up design, space available for the setup, shock load conditions, issues with static dissipation, the service life of the belt etc.

Types of Belt Drives:

There are two broad classifications as far as types of belt drives are concerned, they are determined by the amount of power transmission required and arrangement of belts.

Belt Drives according to the power transmitted:

Light Drives:

Used in agriculture machines and small machines. The belt speed generally remains in the range of 10 m/sec. Perfect for applications where small power transfer is required.

Medium Drives:

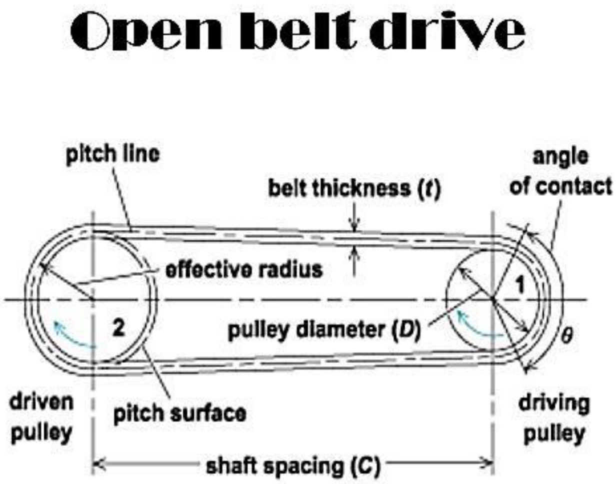
Used in industrial and semi-industrial applications the power delivery in this set up is of medium range. Highly utilized in machining and similar applications the belt speed in this type of setup ranges from 10 m/sec to 22m/sec.

Large Drives:

As the name suggests these are big belt drives used for heavy power delivery. It finds wide application in processes where high transmission power is required. The belt speed in this format of the belt drive is in excess of 22 m/sec. It finds application in running of compressors and similar large machinery.

Belt Drives according to the arrangement of belt:

Open Belt Drive:

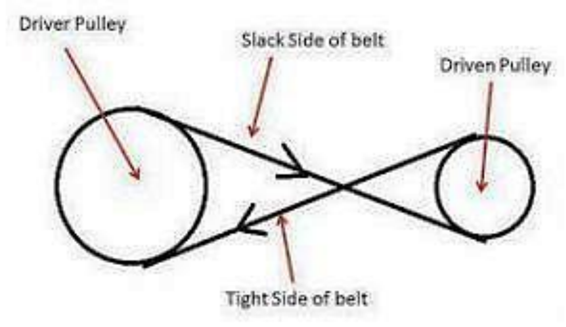


Open belt drive

In this type of belt drive, the assembly of shafts is parallel and rotates in the same direction. The size of the shaft varies and has a large shaft connected to a small shaft. The power is transmitted from the larger shaft to the smaller shaft, the lower side is known as the tighter side.

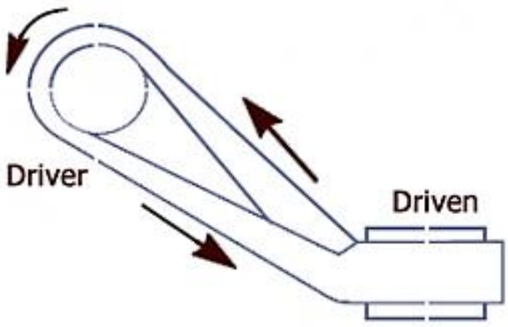
Cross belt drive:

In this type of belt drive, the shafts are parallel to each other just like in open belt drive but the belts are in cross configuration and moving opposite to in each other in direction. In this configuration, the same layout of one shaft is bigger than the other is applied. Crossed belt drive has more tension on the side which is acting as the driver i.e. the direction in which the belt is being moved. The side being pulled in known as the tight side and the other one is known as the slack side.



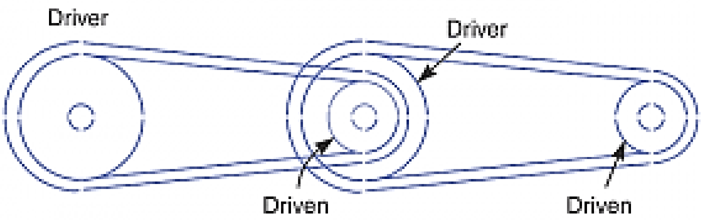
Cross Belt Drive

Quarter Turn Belt Drive:



This type of belt drive is also known as right angle belt drive. In these configurations, the shafts are at the right angle and move in one direction. This provides for a unique problem and that is the belt running down the pulley, to overcome this problem the width of the shaft is quarter times more than the width of the belt. Hence the name quarter turns belt drive.

Compound Belt Drive:



As the name suggests, compound belt drive is a complex arrangement of shafts and pulleys where power is transmitted from more than one shaft utilizing a number of pulleys. It is generally used in a complex application environment.

Question Four

Explain Bernoulli's Equation & Applications

Bernoulli's Equation & Applications of Bernoulli's Equation?

Bernoulli's Equation is one of the most versatile equation ever.

This is an important principle involving the movement of a fluid through a pressure difference. Suppose a fluid is moving in a horizontal direction and encounters a pressure difference. This pressure difference will result in a net force, which by Newton's 2nd law will cause an acceleration of the fluid. The fundamental relation,

$$\text{work done} = \text{change in kinetic energy}$$

in this situation can be written as-

$$-\text{ (change in pressure) x area x distance} = \text{change in kinetic energy,}$$

which furthermore can be expressed as

$$\text{change in pressure} + \text{change in (kinetic energy / volume)} = 0.$$

In other words,

$$\text{Pressure} + \text{(kinetic energy / volume)} = \text{constant}$$

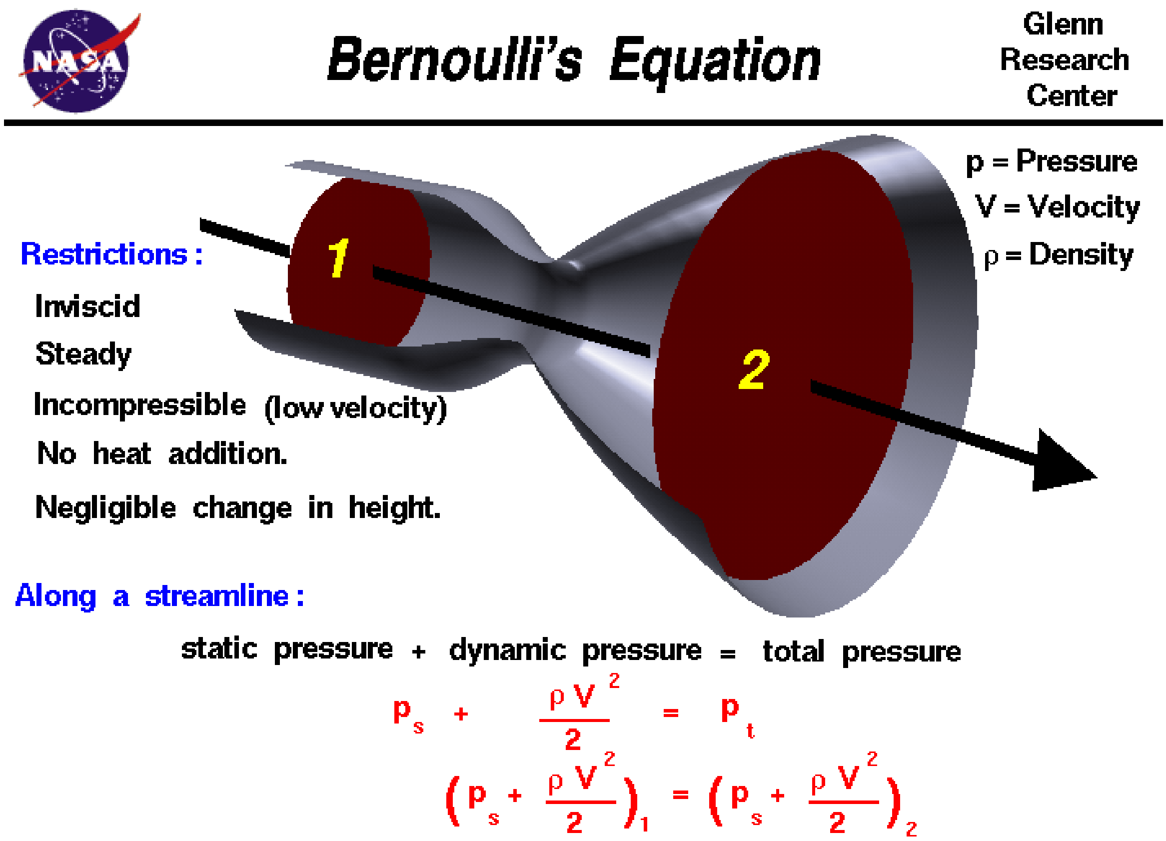
This principle is generally known as the **conservation of energy principle** and states that the **total energy** of an isolated system remains constant — it is said to be conserved over time. This is equivalent to the **First Law of Thermodynamics**, which is used to develop the general energy equation in thermodynamics. This principle can be used in the analysis of **flowing fluids** and this principle is expressed mathematically by the following equation:

$$\rho \frac{Dh}{Dt} = \frac{Dp}{Dt} + \nabla \cdot (k \nabla T) + \Phi$$

where h is enthalpy, k is the thermal conductivity of the fluid, T is temperature, and Φ is the viscous dissipation function.

Bernoulli’s Equation-

Bernoulli’s Equation & Applications of Bernoulli’s Equation



The Bernoulli’s equation can be considered to be a statement of the **conservation of energy principle** appropriate for flowing fluids. It is one of the most important/useful equations in **fluid mechanics**. It puts into a relation **pressure and velocity** in an **inviscid incompressible flow**. **Bernoulli’s equation** has some restrictions in its applicability, they summarized in following points:

- steady flow system,
- density is constant (which also means the fluid is incompressible),
- no work is done on or by the fluid,
- no heat is transferred to or from the fluid,
- no change occurs in the internal energy,
- the equation relates the states at two points along a single streamline (not conditions on two different streamlines)

Under these conditions, the general energy equation is simplified to:

$$p_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = p_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

This equation is the most famous equation in **fluid dynamics**. The Bernoulli's equation describes the qualitative behavior flowing fluid that is usually labelled with the term **Bernoulli's effect**. This effect causes the **lowering of fluid pressure** in regions where the flow velocity is increased. This lowering of pressure in a constriction of a flow path may seem counterintuitive, but seems less so when you consider pressure to be energy density. In the high-velocity flow through the constriction, kinetic energy must increase at the expense of pressure energy. The dimensions of terms in the equation are kinetic energy per unit volume.

Applications of Bernoulli's Equation:

Bernoulli's equation is used any time we want to relate pressures and velocities in situations where the flow conditions are close enough to what is assumed in deriving Bernoulli's equation. You need to be in a flow that is not changing with time and in a regime for which the fluid behaves pretty much like an incompressible fluid without viscosity.

If the flow is dominated by viscous stresses (low Reynolds numbers), then Bernoulli's equation cannot be used. We can still use it for parts of the flow where viscosity isn't so strong, but inside the boundary layer, for example, we cannot use it.

If the flow is highly unsteady, then it cannot be used. In some cases, we might be able to use it, but we have to be careful about how we do it.

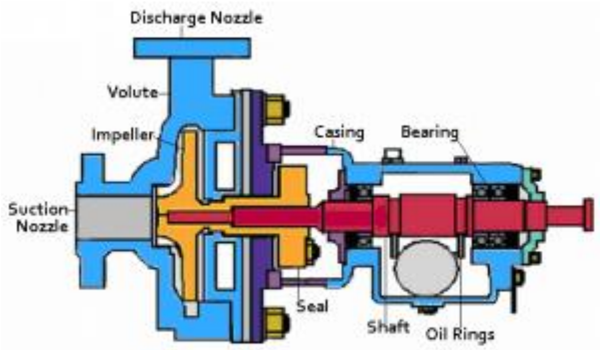
The incompressible version can only be used if the effects of compressibility are small. That typically means lower than about Mach 0.3. But even at somewhat higher Mach numbers, you can still use it to get a rough idea about the flow. Just remember that your results are distorted, so don't assume they have a lot of accuracies.

We use Bernoulli's equation for a lot of different fluid flow situations.

Question Five

Explain Centrifugal Pump: Principle, Parts, Working, Types, Advantages, Disadvantages with its Application?

Centrifugal pump is a type of turbomachinery which is dynamically axisymmetric and work absorbing in nature. In more simpler terms it's a pump which is used to lift liquids from a lower area to a higher area. Its most widely used in industries where sensitive fluids as in chemical industries are required to be moved.



The basic principle of centrifugal pumps is the conversion of rotational kinetic energy to hydrodynamic energy of fluid movement. The fluid enters through the pump impeller near the rotating axis and gets accelerated reaching the desired destination.

Parts of a centrifugal pump:

Rotating Parts:

Impeller:

It is the heart and soul of a centrifugal pump it has following subtypes.

Open Impeller:

This impeller does not have a crown and base plate, it finds wide application where physical impurities in the liquid to be pumped has to be kept at bay.

Closed Impeller:

It is completely covered with no scope of any foreign body entering. Widely used for pumping water.

Semi-Open Impeller:

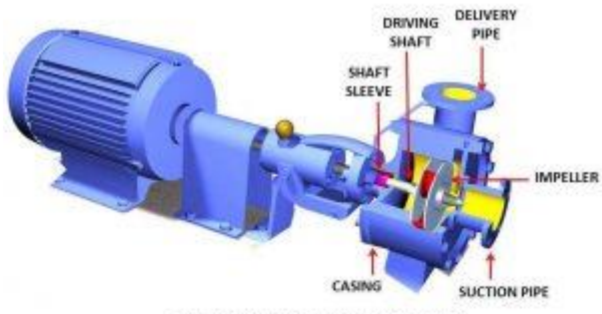
Lacks a crown plate and is suited for fluids which might have charged debris in them.

Shaft:

This is the component which is responsible for the rotation of the impeller. It also transmits torque to the impeller and keeps it in sync with other components of the centrifugal pump.

Shaft Sleeve:

It's a covering for the shaft assembly and protects the unit from corrosion. Its open from one end.



CENTRIFUGAL PUMP

Casings:

Casings used in a centrifugal pump are of two types: the volute casings and vortex casings. Volute casings are funnel-shaped and are designed to reduce the overall pressure of the fluid on the shaft of a centrifugal pump. It acts as a safety measure and keeps the fluid velocity in check, on the other hand, vortex casings have vanes which convert the kinetic energy into pressure.

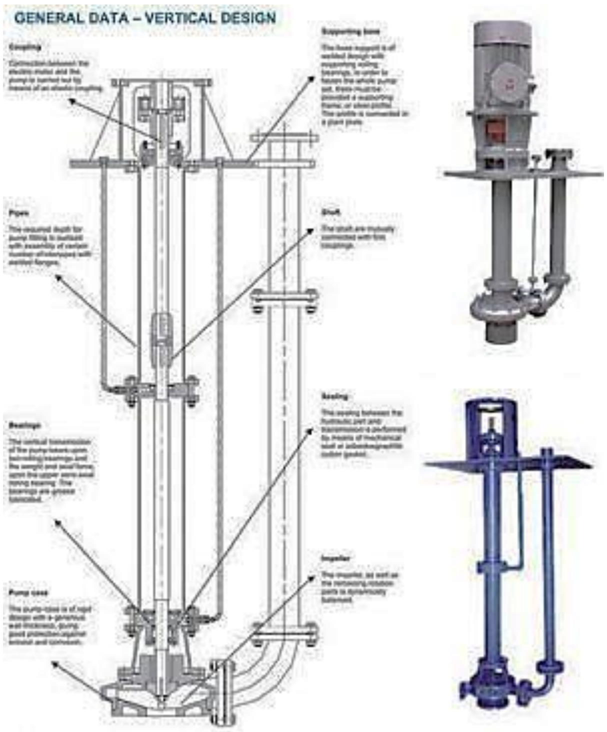
Suction Pipe:

It’s a pipe which connects the source of the fluid or the liquid to be pumped to the centrifugal pump. Generally, the lower end of the pipe which gets dipped in the fluid has a strainer which acts as the first line of defense for debris and other non-desired material from entering the pump. Also, a valve is present which only allows the upward movement of the fluid.

Types of centrifugal pumps-

Vertical Centrifugal Pumps:

They are also known as cantilever pumps, they are unique in design as it allows for the volute to hang in the sump while keeping the bearings outside the sump.

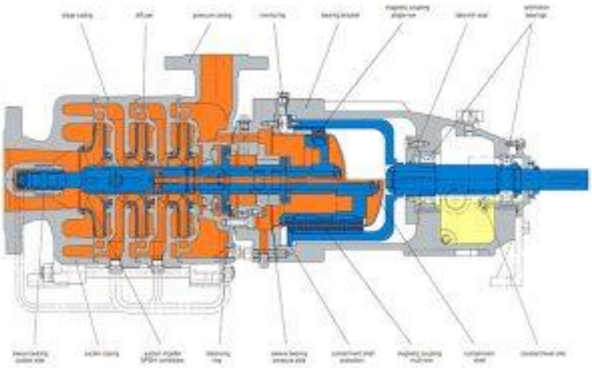


Froth Pumps:

It is a kind of open impeller centrifugal pump and is widely used in minerals industry or the industries where keeping the impurities at bay becomes crucial. In mining for minerals, a lot of froth is generated, this froth over the course of time generates air which blocks the conventional pumping setup, froth pumps act as a remedy to this problem.

Multistage centrifugal pumps:

It's the most complex type of centrifugal pump and has a unique configuration. In this type of pump, the impellers can be mounted on a single shaft or on multiple shafts depending upon the use. This pump also has many stages of fluid movement. In every stage, the fluid is moved to center before getting discharged. In case of higher pressures, the impellers are connected in series and for the higher output, they are connected in parallel.



Advantages of centrifugal pump:

- No leakage issues.
- Can be used for pumping sensitive fluids like petrol and diesel.
- No loss of power due to friction.

- Economical to operate

Disadvantages:

- At times clogging of pipes may occur
- Any external vibration can damage the pump
- Low flow may cause overheating
- Risk of cavitation is high

Question Six

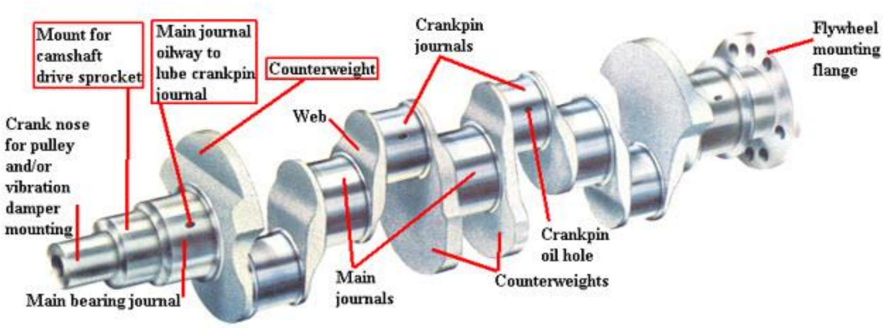
Definition of crankshaft and its basic functions

The crankshaft is an essential part of the engine responsible for converting reciprocating to rotational motions. In a simple language, it is a shaft with a series of crank and crank pins, which are attached to the connecting rod of the engine. Nowadays the large engines have multi-cylinders and the crankshaft is necessary to drive the pistons.

You cannot find such mechanism in single cylinder engines as they have an only single piston in it. These parts are made with the forging processes and need careful designing to reduce the effect of vibrations. Let’s learn about this product and its functions.

Functions of the Crankshaft in an Engine

This mechanism is very necessary to provide a smoother drive to the large engines which have multi-cylinders. They are responsible for transforming the linear motion of the piston into the rotational motion. This specific part of the engine is made with the process of forging the alloy of iron ore called steel.



While visually inspecting the crankshaft, you can find the rod bearings are nearly offset or eccentric. Here the offset of the shaft transforms the reciprocating motion (up and down) of the piston in the rotating motion of the crankshaft.

Most often the shaft is drilled with minute holes which feed the engine with the oil necessary for smooth operations. Sometimes, this mechanical part consists of

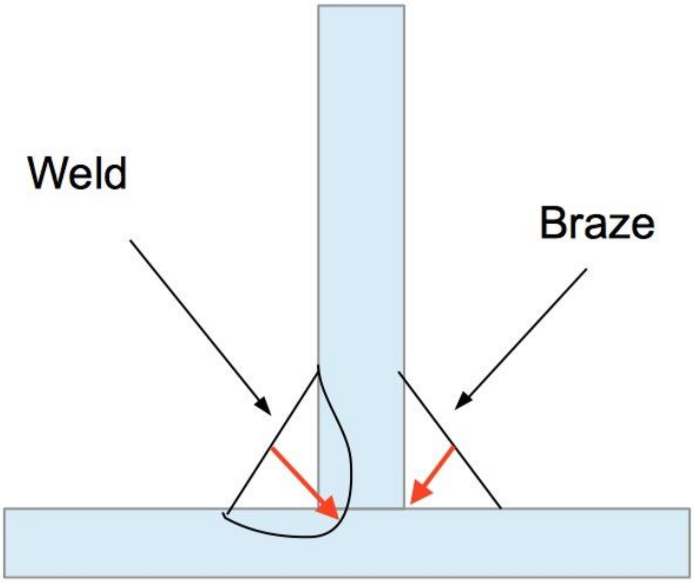
counterweights which help in balancing the system and the weight of the connecting rod. It also ensures to balance the force while rotation of the moving parts.
Every engine is designed specifically and so is the crankshaft. Its design varies with the size and number of cylinders in the engine. Featuring an example, in a four-stroke engine, the crankshaft will have four crank throws. These throws connect the four pistons and are efficiently connected to the flywheel of the engine.
While driving the engine or during the combustion cycle the crank throw works as a lever arm, which pushes and pulls the piston. This considerably creates a successive rotational motion in the engine.
The crankshaft helps the piston to complete its rotation and the throw will return the piston at the top of the cylinder. This product needs very sleek designing while production with respect to its weights and balancing. Such engineering is necessary to reduce the vibrations in the engine. Such, vibrations can be very harmful to the vehicle and can even lead to major accidents.

Question Seven

What is the Difference between brazing and welding

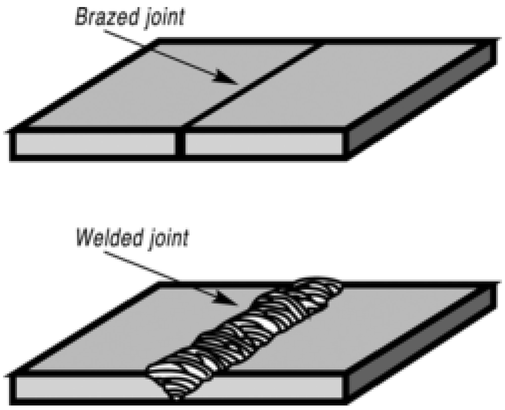
Difference between brazing and welding

Several processes are used to join the different metal parts. Among all of those processes, brazing and **welding** are used to fill or join or fix in the gaps in metals. These two processes serve the same purpose. However, their modus operandi is different. Both the processes differ in terms of their temperature, base metals and melting point temperature of the filler.



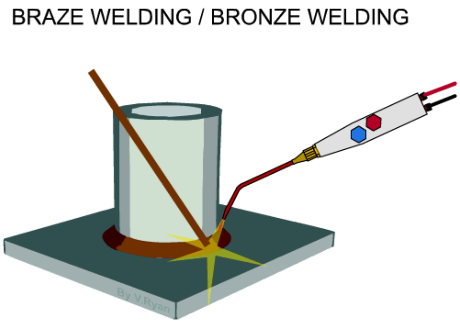
Talking about the **welding**, it is the most common process that is used to join the two metal pieces and the thermoplastics. In this process, the base metal is melted along with the filler electrode to form a weld pool of molten metal. This weld pool gets solidified and makes a strong joint. Sometimes pressure can be also applied along with the heat for the **welding**. **Welding** also needs a shield that protects the filler metal from getting contaminated or getting oxidized. There is also a solid-state welding process – friction welding. It uses the heat generated from friction to weld the metal.

Welding can be performed by using various energy sources like gas flames, laser, electron beam, ultrasound, and friction. This process can be performed under different environmental conditions including underwater, outer space and open air. It is a dangerous process and needs precautions to avoid any electric shock, vision damage or poisonous gas inhalation.



In brazing, only the filler metal is melted to make a joint between the two metals. The wetting is formed between the metals to be joined together and it gets solidified, resulting in a stronger joint. The filler metal goes between the close-fitting parts by capillary action. Brazing is similar to the soldering process. Through these statements, we can say that in **welding** both base metal and filler metal are melted whereas in brazing process only filler metal is melted to make a joint.

In the **brazing** process, it is necessary for both the parts to be joined together don't have oxide layer over their surface. In case, the oxide layer is present, then it should be cleaned using mechanical or chemical cleaning process. Moreover, in this process, the base metal is not heated to their melting point, but filler metal is heated to its melting point. The processes involve different temperature range as compared to one another.



In **welding**, a high temperature is required to melt both base metal and filler metal, but in **brazing**, the temperature is low as compared to the **welding** process.

The **brazing** gives a considerable strength to the metal.

Another aspect that differs **brazing** from other metal joining process is its temperature. In **brazing**, the temperature should be in such a range that it is higher than the melting point of its filler metal.

Question Eight

Difference between Casting & Forging

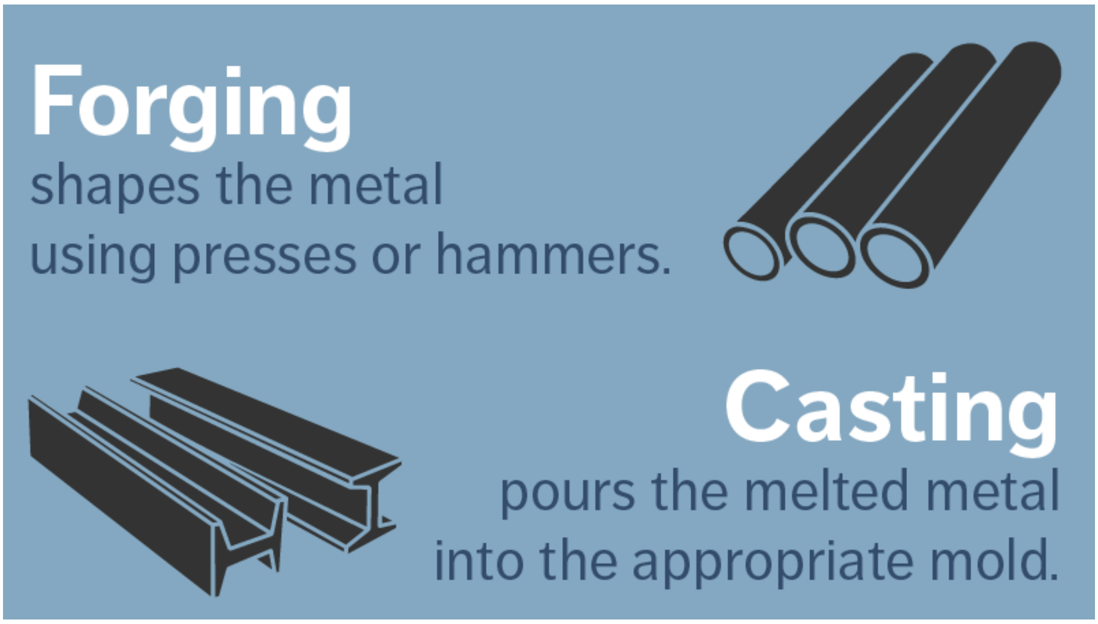
This question, "**Forging vs. Casting: Which is better?**" is one that I have been asked many times. To properly explore the answer, let's first consider the process of each.

Casting:

In this process, the metal is heated until molten. The molten metal is then poured into a vessel or mould to get the desired shape.

Forging:

In this process, the metal is heated and then bent or beat into the desired shape using external physical force.



Why use Casting?

We use casting for wear parts that are too large, complex and can't be easily forged. For forging large pieces of a metal huge amount of sheer force is required so casting is a better alternative. There are no such size limits for metals in casting. It is way more beneficial because –

-No such difficulty in casting complex parts.

-No size limitations

-Lesser workforce

-Comparatively easier than forging

Why use Forging?

Forged steel is stronger and more reliable than castings. Forged parts have higher tensile strength than cast parts. Forged parts also have higher fatigue strength. Forging is used because-

-Will handle impact better than cast one

-The nature of forging excludes the occurrence of porosity, shrinkage, cavities and cold pour issues.

-The tight grain structure of forgings making it mechanically strong. There is less need for expensive alloys to attain high strength components.

-The tight grain structure offers great wear resistance without the need to make products “super hard” We have found that on a blank HRC 38-42 forged grinder insert wear/wash is about the same as a high alloy HRC 46-50 cast grinder insert. The difference being an HRC 46-50 casting does not have the ductility to handle high impact grinding.

Question Nine

Difference Between Fan and Blower

A fan and a blower although having the same working principle and somewhat same functionality have some very stark differences in them. In this article, we will make a sincere attempt at making a clear distinction between the two and at the same time review some of its fundamentals.

Fans and blowers are technically both mechanical devices working for displacing air in the given area. However, a fan is used to distribute the air at larger and vague areas and a blower is used to concentrate the air flow to a particular area.

The major difference that has to be understood while differentiating both is that a Fan is an electrical device whereas a Blower is a mechanical device to which a fan is attached. A blower cannot function without a fan attachment. The fan in case of the blower is the source of air which it redirects to a particular point or location.

Fans and blowers have wide utility, they are used almost everywhere, a car has both fan and blowers in it. A fan might be found in the AC condenser area of a car and a blower would be found acting as a source of cool air inside the car in form of AC duct. Fans displace a large amount of air over the large surface at a low pressure whereas a blower displaces a moderate amount of air towards a particular direction with a moderate amount of pressure.

In case of the fan, the ratio of pressure is below 1.1, whereas in case of a blower the ratio of pressure is between 1.1 and 1.2.

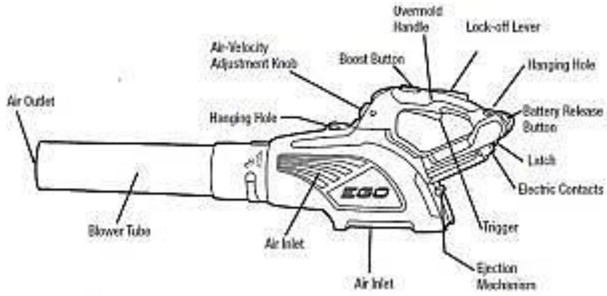
The axial flow, centrifugal and cross flow are the three most common types of fans whereas blowers are only of two types, the centrifugal blower, and the positive displacement blower.

The fan consists of motor blades whereas a blower consists of a housing casing with a fan.

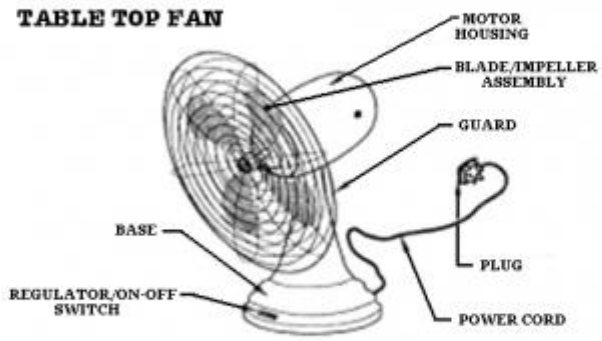
Axial Fan

Centrifugal Blower

There are more differences between a fan and a blower, for example, a blower generally has a very specific usability spectrum. Blowers have a good acceptability in fields of applications where a concentrated beam and consistent air flow is desired. Like in a furnace or certain type of blowtorch applications the blower would be the preferred source of air. Blowers are also good companions for kitchen ovens and grills where continuous air supply is required for proper combustion of fuel.



On the other hand, fans are widely used for cooling purposes, fans generally work under a consistent temperature range and are not subject to any environmental extremes. They are heavy duty equipment and have a sturdy long lasting built quality.



Fans are easy to maintain and repair and can be cleaned easily just because of their simple operational needs whereas a blower might need some serious maintenance efforts as depending upon the application it may or may not be subjected to harsh working conditions and extreme debris and effluents.

A blower used in the industrial application will surely be exposed to high temperature, humidity and ash and similar kind of industrial waste which can impact its service life and durability.

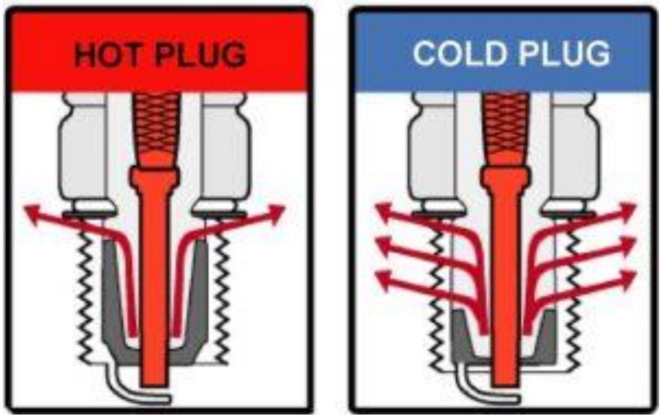
A fan would essentially be powered by electricity in current scenarios whereas a blower also has a human labor-centric option where a handle is used to drive the fan unit of the blower. There is also a clear difference between the cost of these two units. A blower most of the times will be expensive than its counterpart within same scale and usability.

Question Ten

Difference Between Hot Spark Plug and Cold Spark Plug Explained

When a plug becomes very hot in an engine, then it's a hot plug. The plug that doesn't reach a high temperature is a cold plug. The metal shell of each plug will function at almost the same temperature as the metal of the head itself because the plugs are screwed into the head and there is a good path for heat flow between shell and head.

Heat collected by the insulator tends to accumulate there because the insulator material is not a good conductor of heat. The track for heat flow is away from the insulator nose. Heat has to flow upwardly along the nose until it reaches the place where the insulator is in mechanical contact with the shell.



Spark plugs are manufactured with different heat ratings, from very cold to very hot, so a desirable plug can be found for your engine, depending on what you need, based on your riding or driving conditions. Plugs with the same diameter and reach will have different lengths of the insulator nose section and different type numbers to indicate which runs hot and which runs colder.

These plugs are mechanically interchangeable but will run at different operating temperatures in the same engine. Part of the tuning problem is to find a plug that survives in an engine.

What happens when the plug is too hot?

A mixture that's too lean will do it because the gasoline drawn into the firing chamber has a cooling effect. If there is not enough gasoline, there is not enough cooling. When a spark plug gets too hot, the insulator may boil and bubble On examination, it will be plain that it has been too hot. Also, the metal electrodes may melt away and disappear. If any of these bad things happen, that's good.

The worst-case scenario of a too-hot plug that fails to destroy itself is when it destroys the engine instead; this is called pre-ignition. If the tip of the plug becomes hot enough to ignite the fresh mixture being drawn into the cylinder, then the incoming mixture will start to burn without waiting for the spark to happen.

Ignition due to any hot spot in the cylinder begins before the proper time for ignition, so it is called pre-ignition. Anything in the combustion chamber which gets hot enough can cause pre-ignition, but typically the end of the spark plug is the cause. When the mixture is firing sooner than it should, that's like advancing the spark too much, and no matter what causes it, early ignition makes engines heat up, causing pre-ignition. Eventually, something melts, which comes under the heading of a bad thing.

What happens when a plug is too cold?

If the nose of the plug is not hot enough, it will gradually accumulate deposits, known as fouling. During normal engine operation, residue from the combustion process hits the insulator nose. This may include carbon, unburned fuel and oil, and chemical additives present in both fuel and oil. If the insulator nose and electrodes are hot enough, the combustion deposits will be continuously burned off by the heat of the plug. The ideal situation is to have the deposits burned off as fast as they accumulate, so the insulator nose stays fairly clean and free of deposits.

If the deposits accumulate on the plug because it is not reaching a high enough temperature to burn them off, the gradual accumulation will eventually short out, or foul, the plug. The fouling is electrically conductive and forms a path along the insulator, which connects the center electrode to the metal shell of the plug.

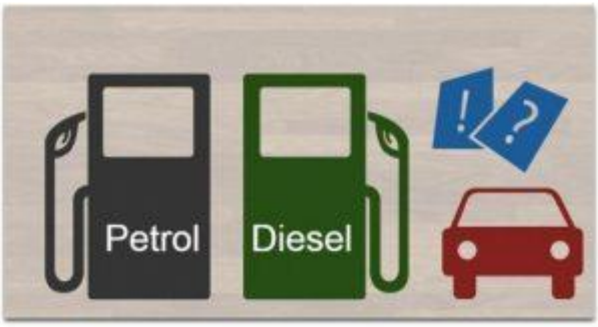
Question Eleven

What is the Difference Between Petrol and Diesel?

Difference Between Petrol and Diesel

Another curious question, in this article, we will talk about the difference between the two most commonly used fuel **Petrol or Gasoline** and **Diesel**.

Petrol and Diesel are used as fuel in IC and CI engines. It is obtained by fractional distillation of crude oil. When crude oil is heated first, LPG gas vaporizes then petrol is obtained. Petrol is a hydrocarbon which contains 4-12 carbon-carbon atoms per molecule. The common molecules found are alkanes, cycloalkanes, aromatic chains, and asphaltenes. These alkanes also are known as paraffin have the chemical formula C_nH_{2n+2}.



The alkane from pentane to octane (C5H12-C8H18) is refined to petrol while the alkane from nonene to hexadecane (C9H20-C16H34) is refined as diesel or kerosene. Diesel fuel is used in compression ignition engines while petrol (or also called gasoline) is used in spark-ignition engines.

Difference between the two:

PROPERTY	PETROL	DIESEL
Chemical name	Mostly cyclic compounds like aromatics and	Straight chain of hydrocarbons

	naphthalene	
Chemical formula	Ranges from C5H12-C8H18	Ranges from C9H20-C16H34
Energy content	Less compared to diesel as it is lighter. Energy content is 33.7MJ/Kg	Up to 16% more energy content than petrol as it is denser. Energy content is 36.7MJ/Kg
CO_2 emission	Less proportion of carbon atoms so less CO_2 emission	More proportion of carbon atoms so more CO_2 emission
Engines	Spark-ignition engine	Compression ignition engine
Viscosity	Less viscous	More as compared to petrol
Volatility	Greater because of the additives	Less volatile
Boiling temperature	350^{o}C-2000^{o}C 34.6MJ/liter	1800oC-3600^{o}C 38.6MJ/liter
Power	Higher RPM for petrol engines	More torque in case of diesel engines
Calorific value	Net calorific value=44.4MJ/kg	Net calorific value=43.4MJ/kg
Flammability	Has high vapor pressure. Hence more flammable	Has less vapor pressure so less flammable
Ignition type	Self-ignition temperature is 2460^{o}C For combustion of this fuel, the spark plug is required	Self-ignition temperature is 2100^{o}C Self-ignited because of temperature rise due to high-pressure compression.

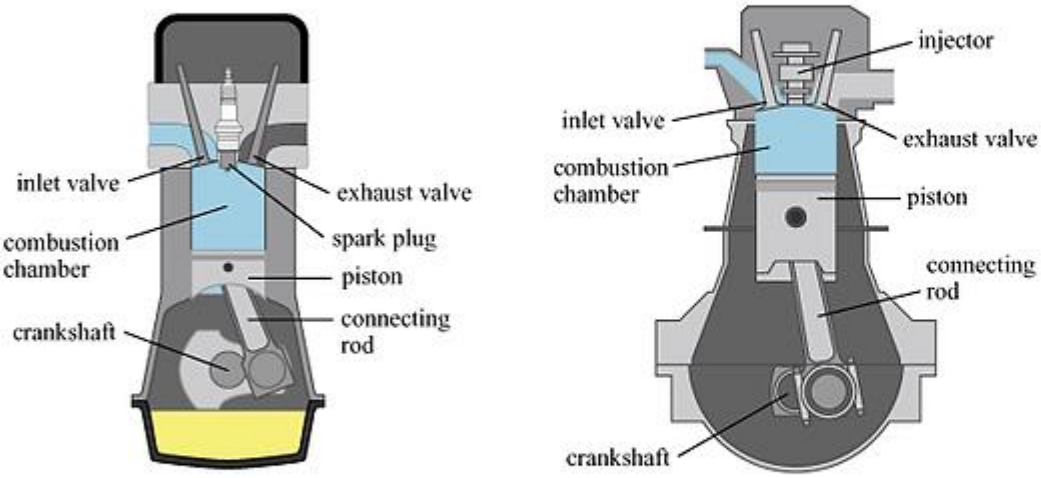
Flashpoint (the minimum temperature at which fuel is available for ignition in the evaporated state)	430ºC	Ranges from 520ºC-950ºC
Fire point (temperature at which fuel tends to burn itself and stays for five seconds)	Near about 440ºC	530ºC-960ºC
Indexing	By octane number, it is the ability to resist auto-ignition.	By cetane number, combustion speed depends on this number
Fuel price	Price is more	Price is less

Question Twelve

What is the Difference Between SI engine and CI engine?

Difference Between SI engine and CI engine

What are these SI & CI engines? The difference is actually the mode by which the fuel is ignited. SI here stands for spark ignition engine and CI here stands for Compression Ignition engine. Today we will try to differentiate between the two.



The basic difference between the two is same as that between a petrol engine and a diesel engine. This line is just for you guys to get a small hint of what we are talking about. So here we go.

Operational Cycle: Now SI or spark ignition engines which are also known as petrol engines ignite their fuels on basis of Otto cycle or constant heat volume addition cycle. Here the ignition is carried out with the help of a spark plug. What the spark plug does is, it introduces a spark into the combustion chamber where the fuel and air mixture are present. Whereas in case of a CI engine also known as compression ignition engine (diesel engine) works on the principle of diesel cycle or constant pressure heat addition cycle. Here the ignition of fuel occurs due high pressure and temperature in the combustion chamber. Hence no spark plugs are required in this case.

Type of Fuel: As mentioned earlier SI or spark ignition engines use petrol for working whereas CI or compression ignition engine use diesel as working fuel.

Method of fuel injection: In spark ignition engines the mixture of fuel and air is introduced at the time of suction. For this, it has a carburetor for mixing fuel and air. Whereas in the diesel engine or compression ignition engine the fuel is directly injected into the chamber at a high pressure. Hence CI engine has a fuel pump and fuel injector.

Compression Ratio:

In spark ignition engine or SI engines the compression ratio varies from 6 to 10. Here the compression ratio upper limit is set by the anti-knock properties of the fuel in use. i.e. the octane rating for the fuel. Whereas in diesel engines or compression ignition engine the compression ratio varies from 16 to 20. Here the upper limit of compression ratio is determined by the weight of the engine.

Speed: Spark ignition engines or petrol engines are high-speed engines. This is because of their low weight and homogeneous combustion. On the other hand, compression ignition engine is low-speed engines owing to their heavy weight and heterogeneous combustion process.

Thermal efficiency: Since spark ignition engines have lower compression ratios the maximum value of thermal efficiency is lower than a compression ignition engine.

Weight: Spark ignition engines are lighter than compression ignition engine. The reason for this is simple. In compression ignition engine very, high operating pressures are present. Hence, they have to have thicker and stronger construction when compared to spark ignition engines.

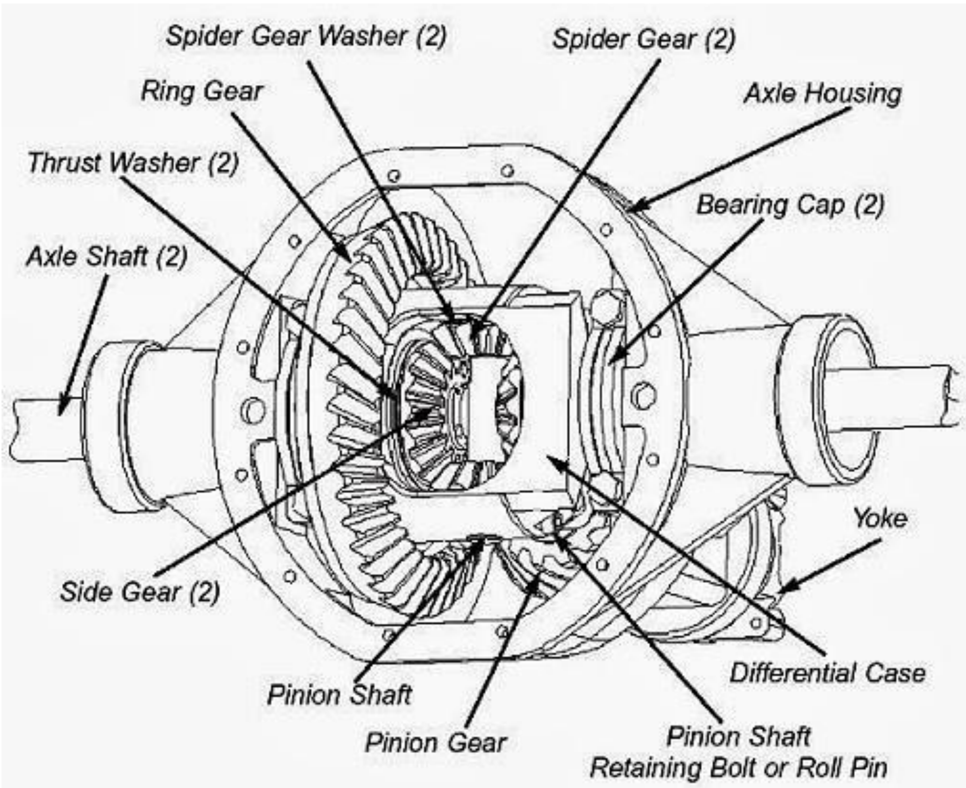
Time of knocking: In spark ignition system, knocking takes place at the end of the combustion process. Whereas in case of compression ignition system knocking takes place in starting phase of combustion. Now, what is knocking anyways? Knocking happens when there is an autoignition of fuel in the chamber. This happens when there are carbon deposits in the engine. What happens is that carbon absorbs heat and does not release it. This results in fuel getting ignited before the desired time.

Knocking can be harmful to the engines. Hence so much emphasis is laid on regular maintenance of the engine.

Question Thirteen

Differential Gear & It's Working

The differential gear is an integral part of all four wheelers. This technology was invented years ago and is termed as one of the most indigenous technologies human brains could ever create. Differential gears are an arrangement of spur gears in an automobile of more than two wheels so that it allows the two wheels on the so-called same axle to revolve at different speeds. Say while turning the outer wheel, i.e. away from the center of the turning needs to revolve more (simple relation of arc = radius * angle).



The main function of the differential gear is to allow the drive wheels to turn at different RPMs while both receiving power from the engine. The differential has three jobs:

To aim the engine power at the wheels

To act as the final gear reduction in the vehicle, slowing the rotational speed of the transmission one final time before it hits the wheels.

To transmit the power to the wheels while allowing them to rotate at different speeds (This is the one that earned the differential its name.)

Why use Differential Gears-

The differential is used in vehicles because during the turning of a car the tires have different speeds due to the different radius of curvature. During straight motion, both tires move with same speed so at that time there is no need of differential, but when the car turns tires must adjust their speeds according to the radius of curvature. If the differential is not used in a vehicle then there is a chance of slip in the tire.

The slippage mainly occurs because the inner wheels & outer wheels rotate at a different speed, the inner wheel will rotate slower than the outer wheels. The differential gear allows two gears on the same axis travels at different angular velocity. There are different number of teeth on each gear and a third gear is meshed horizontally with the two gears facing each other. Differential gear consists bevel gear planet gear those are connected to output shafts.

Question Fourteen

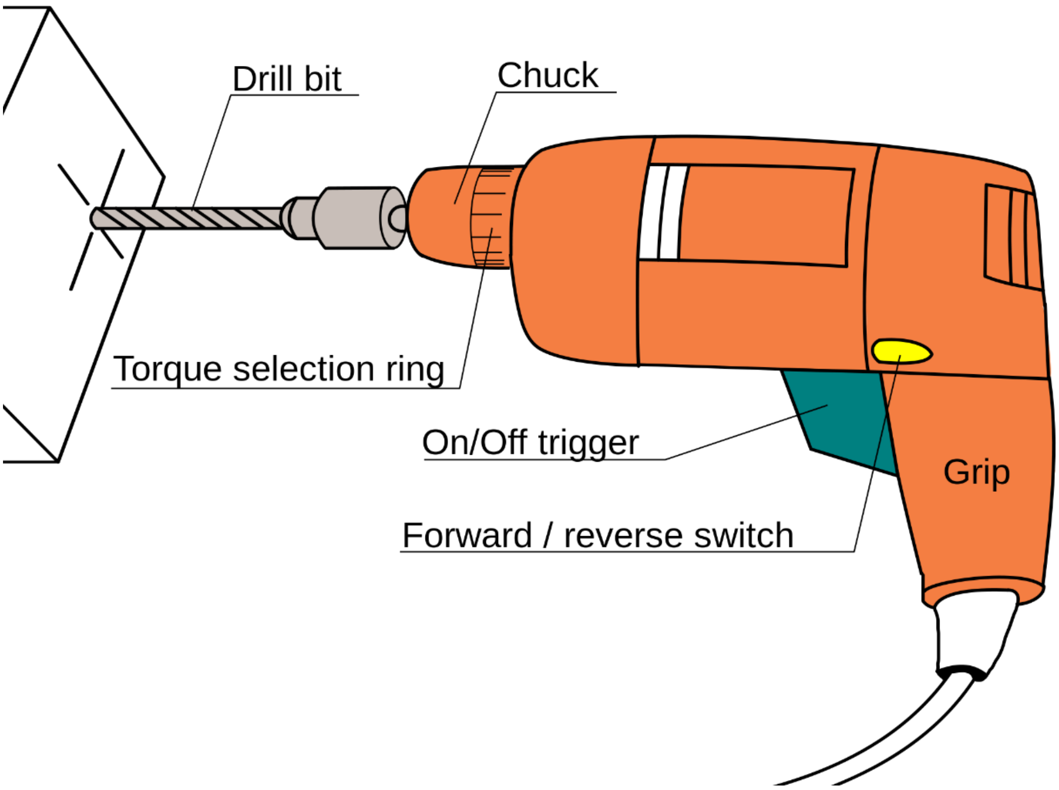
Drilling Machine – Types & Working

A drilling machine is a tool which we use to cut something. Drilling machines consist of a cutting tool attachment, called the drill bit. This part is the core of a drilling machine, and its tip pierces the material and drills through it. There is a base which supports this drill bit and rotates it. So, the *fundamental process* of drilling is **rotating the drill bit while pressing it against a material**. This results in cutting or piercing of the material.

A drilling machine can also be used to make large holes in comparatively softer materials. Using special drill bits, one can make holes in glass.

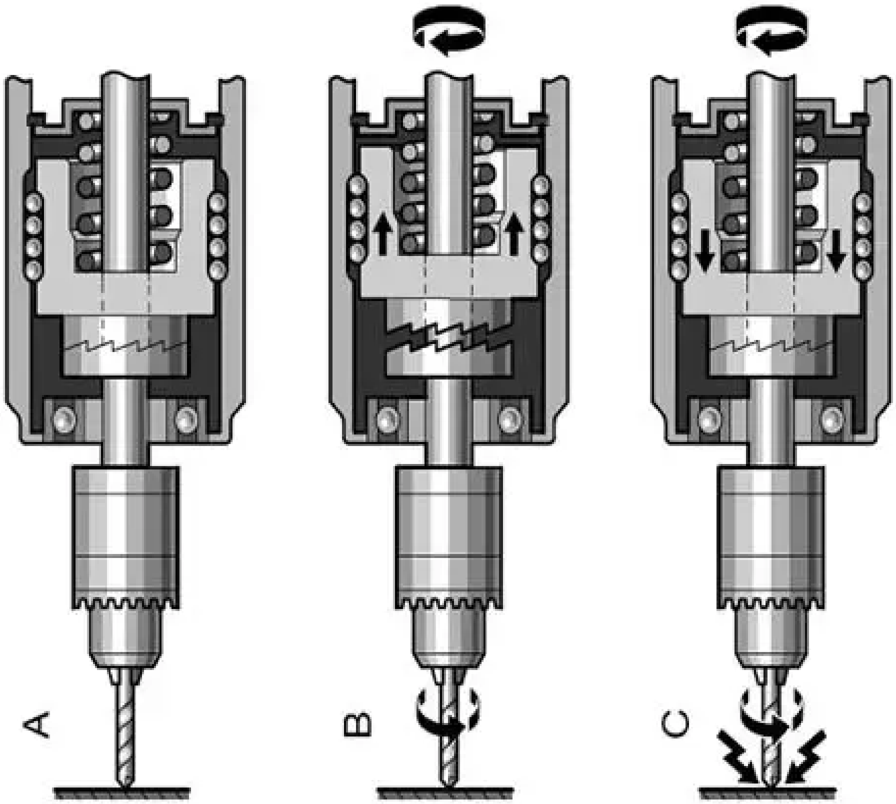
Drilling machine is classified depending upon its mechanism and its applications

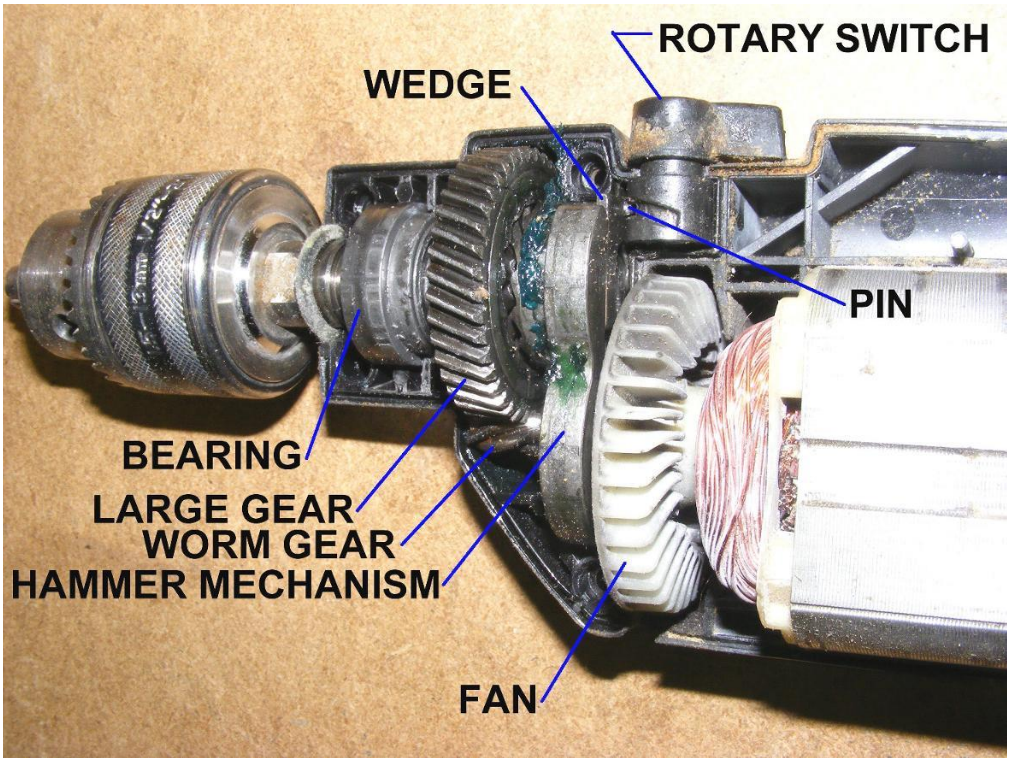
1.Drill/Rotary Drill: This is a general hand-held electric drill machine, having a normal drill chuck. It is used for drilling in wood, metal and plastics. also used for screw driving.



2. Impact Drill/Percussion Drill:

This is similar to normal drill machine as mentioned above, but it has an additional gear mechanism as shown below





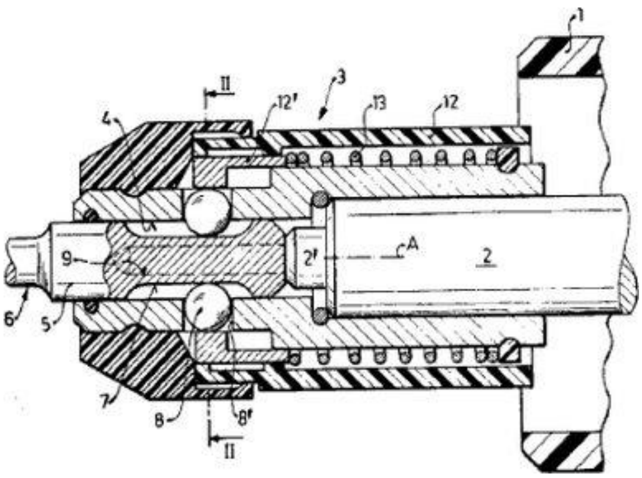
When you turn the rotary switch to impact drill mode it will engage a pulsating gear to the drill spindle and make the drill bit to move forward and backward towards the wall, which works like a chisel while it rotates to break the stone and hardened cement.

Impact drills are used for multiple applications like drilling on brick/masonry wall, concrete (without reinforcement) when you put the machine on impact mode. you can use it as a normal drill for drilling on wood, metals, plastics and screw driving when you put it in normal drill mode.

3.Rotary Hammer/Hammer drill/SDS hammer/Combi hammer etc.:

These drill machines are entirely different from the above and it has pneumatic hammering mechanism with a piston and cylinder to produce higher hammering force.

These drills have a Special Direct System (SDS) instead of a normal drill chuck, which enable key less fixing of drill bit in the machine (just push it in will get locked)



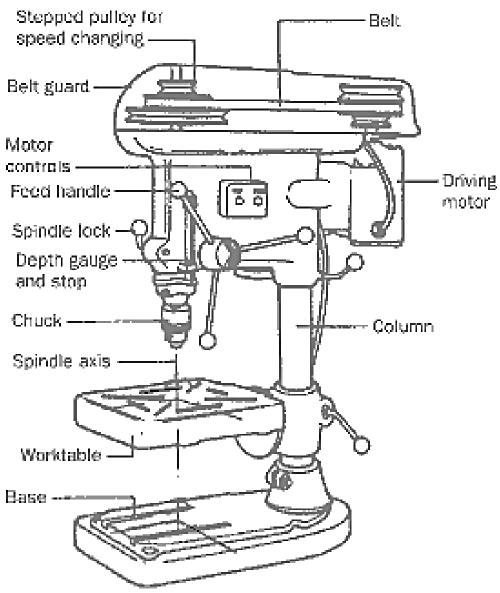
Rotary hammers are mainly used by construction professionals and contractors for drilling and breaking of Masonry/Concrete/RCC/High-strength Concrete surfaces. These drill machines come in 2 or 3 modes, in 2 modes drill you can use Rotary drilling and Hammer drilling functions, and in 3 mode drill, you have a hammer only mode and an additional function called chiseling/chipping can be used for breaking and demolition of concrete/masonry surfaces.

4.Drill Driver: These are similar to rotary drills, but having an additional torque control clutch mechanism for controlling the tightness of screws/bolts.

Drill drivers are mostly used for screwing on wood and metal surfaces and it can do normal drilling work.

Drill drivers mostly available in Battery powered(cordless) version for convenience.

5. Bench drills: These are conventional drill machines mounted on a bench or floor. it has a belt drive and standard chuck. Used for heavy duty drilling on metals and wood.



Question Fifteen

What is the Difference between First Angle and Third Angle Orthographic Projection

First Angle and Third Angle Projection

First of all, we know that the first angle projection system and third angle projection system both are the methods used for orthographic projection drawing.

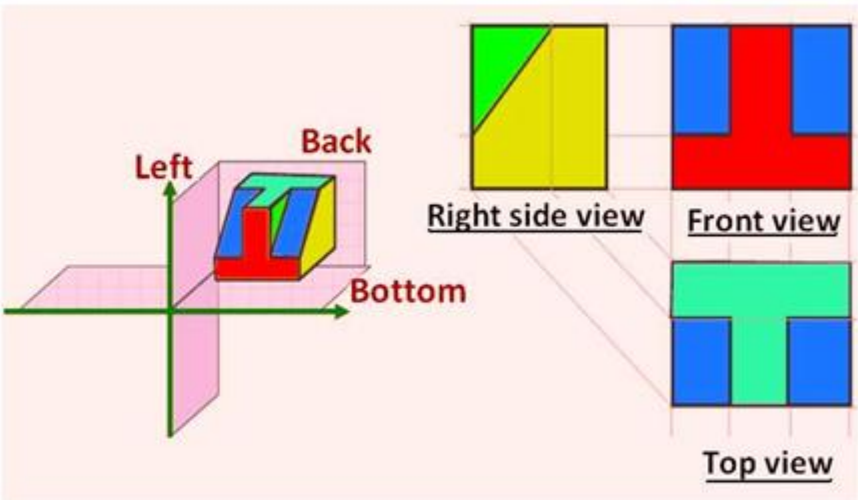
In the first angle projection system, the object placed in the first quadrant and in third angle projection system the object placed in the third quadrant.

If one regards the artesian coordinates as being made of quadrants, then 1st angle and 3rd angle are two different quadrants in which an object is places and different planes on to which the drawing is projected.

In 1st angle, the object is between the observer and the plane of projection. In 3rd angle, the plane is between the observer and the object.

First Angle Projection:

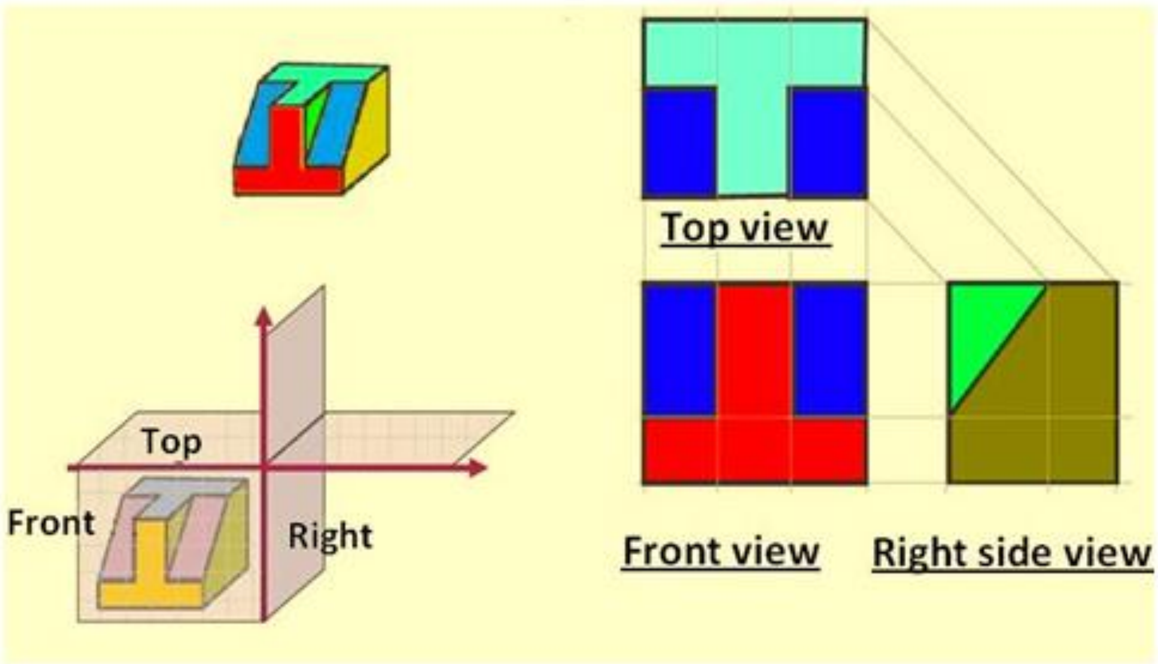
In this, the object is assumed to be positioned in the first quadrant and is shown in figure. The object is assumed to be positioned in between the projection planes and the observer. The views are obtained by projecting the images on the respective planes.



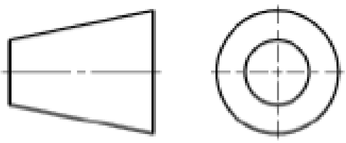
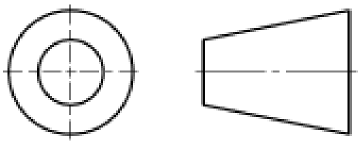
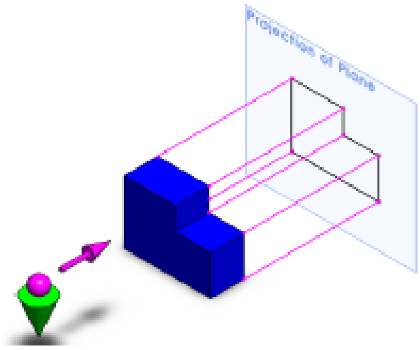
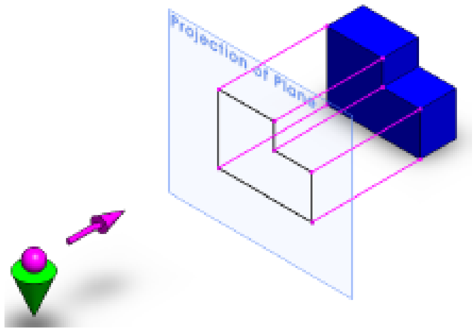
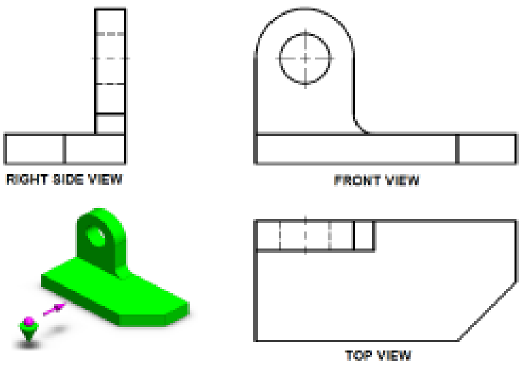
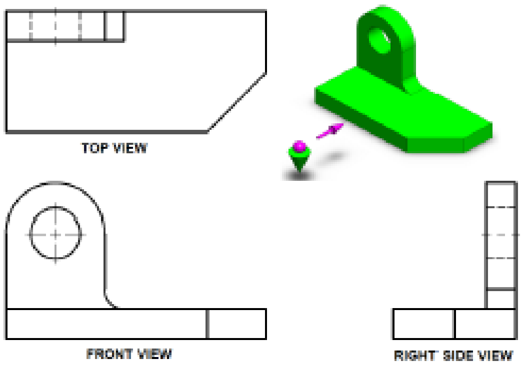
Note that the right-hand side view is projected on the plane placed at the left of the object. After projecting on to the respective planes, the bottom plane and left plane is unfolded on to the front view plane. i.e. the left plane is unfolded towards the left side to obtain the Right-hand side view on the left side of the Front view and aligned with the Front view. The bottom plane is unfolded towards the bottom to obtain the Top view below the Front view and aligned with the Front View.

Third Angle Projection:

Here the object is assumed to be in the third quadrant. i.e. the object behind vertical plane and below the horizontal plane. In this projection technique, Placing the object in the third quadrant puts the projection planes between the viewer and the object and is shown in figure.



The Difference:

First Angle Projection	Third Angle Projection
The object is imagined to be in first quadrant.	The object is imagined to be in third quadrant.
The object is lies between the observer and plane of projection.	The plane of projection lies between the observer and object.
The plane of projection is assumed to be non transparent.	The plane of projection is assumed to be transparent.
When view are drawn in their relative position Top view comes below Front view, Right side view drawn to the left side of elevation.	When view are drawn in their relative position Top view comes above Front view, Right side view drawn to the right side of elevation.
 SYMBOL	 SYMBOL
	
	
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Question Sixteen

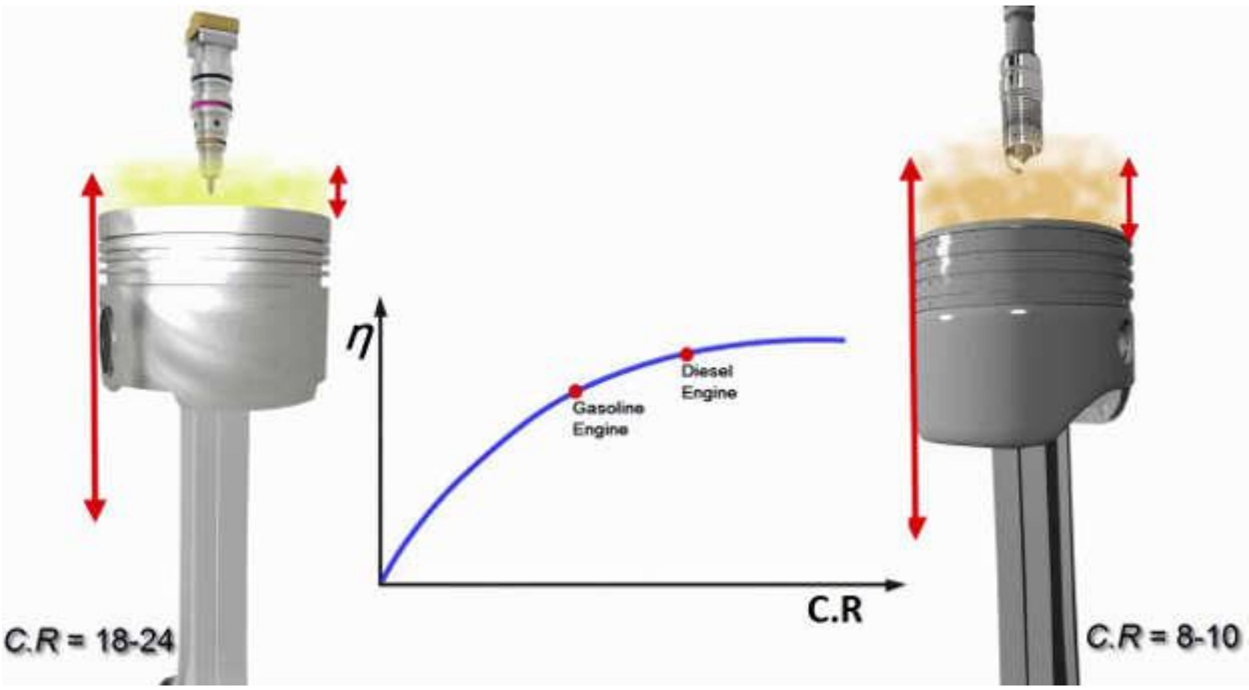
Five Reasons Why Diesel Makes More Torque Than Gasoline

The Diesel Engine is known for more power and better efficiency. Now the reasons why the diesel engine produces more torque are listed below.

Compression Ratio:

In both the engines when the piston moves towards the T.D.C, The Piston of the Diesel Engine compresses the air further more than its T.D.C. This is because in the diesel engine for instant combustion of the fuel heat of the air is required. Thus, it raises the temperature above its self-ignition temperature for self-combustion. While in a Gasoline engine we do not require the air to be compressed more as a spark plug is used to ignite the fuel-air mixture and combustion to take place.

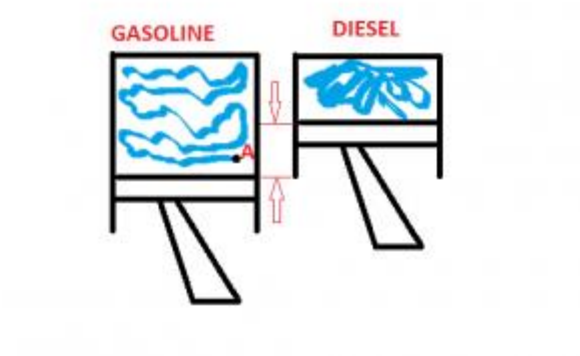
The following graph will show the efficiency of the Diesel Engine is more with respect to compression ratio:



Compression Ratio and Efficiency Graph

Faster Combustion:

As we know in a gasoline engine the spark plug ignites and the flame travels till it burns all the air-fuel inside the cylinder whereas, in a diesel engine, complete combustion occurs as soon as the fuel is injected in thus combustion occurs much sooner.



Cylinder Piston for Gasoline and Diesel

That is, in a diesel engine the fuel spends more time in pushing down the piston whereas in gasoline engine translates into useful work. In the gasoline engine if the combustion still occurs (suppose at a point A) that will move the piston down for short duration only. But if it would have occurred at the top it would have moved the piston for the entire length. So, the compression ignition property of the diesel engine gives more torque.

Bore Stroke Length:

The diesel engine actually has longer stroke length. For a gasoline engine, the bore diameter is more but the piston does not travel much up and down while in a diesel engine the bore diameter is not much wide but the piston moves quite more up and down. Now torque is the force multiplied by the distance. So, in a diesel engine, the force is more and the distance of the stroke is more.

Diesel Engines are Turbocharged:

Diesel engines use heavy-duty pistons, iron blocks, connecting rods, crankshaft all of which add together to make a heavy engine that can handle the increased torque that is produced by the diesel engine. Also, the air-fuel ratio for diesel is 18:1 to 70:1.

They burn lean and thus have more air to compress and produce more work. Pumping loss is also not there during the intake making the engine more efficient.

Calorific Value:

The diesel fuel has slightly lower calorific value than petrol. So, more heat is stored in the petrol for the same volume of given diesel. But diesel is much denser than petrol and can store 15% more energy. So, each time diesel is combusted it produces more energy to pressure the piston and more torque to the crankshaft.

We Hope that now you know Why a diesel engine produces more Torque than a Gasoline.

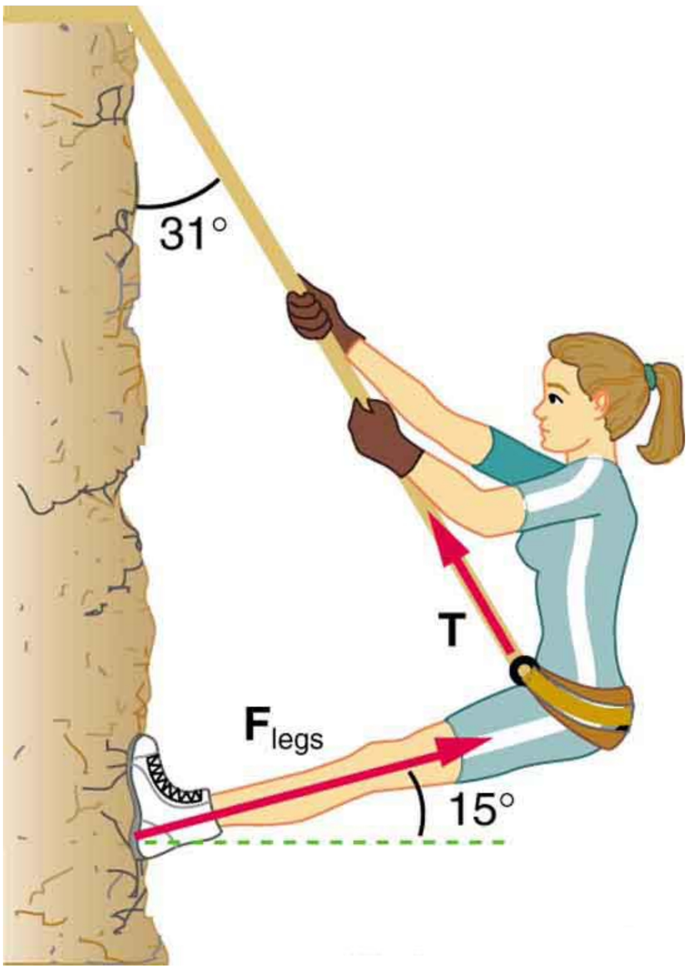
Hope you Liked what we have offered.

Question Seventeen

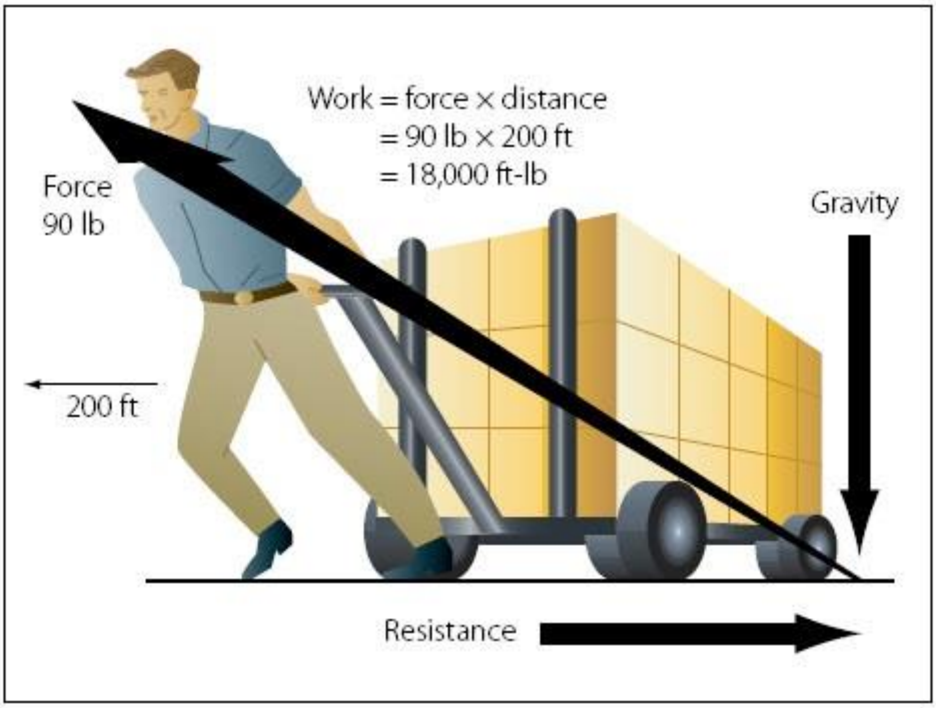
Friction Force & Its Types

Friction is a force between two solid surfaces which are in contact with each other and which opposes the relative motion between the two. The friction arises because of two reasons. One is, that the surfaces are not smooth on a microscopic level and that leads to rubbing of the two, producing a force opposing to the motion. Second is the interaction between molecules of the two surfaces.

If the interaction is attractive, the motion between the two surfaces is opposed. The frictional force can never be eliminated but can be reduced by making the surfaces smoother or by inserting some smooth material (like power or liquid) between two surfaces. The force is considered to be independent of the relative velocity between two surfaces but this is an approximation.



What is described above is sliding friction. There is another concept of rolling friction where when two bodies are moving relative to each other, the surface in contact is stationary. This happens when a wheel is rolling on a plane. Here the part of the wheel which is in contact with the plane is not moving and therefore there is no sliding of the two surfaces. But there is still some frictional force because when the wheel rolls, the part of wheel which is in contact with the plane has to be separated and that requires some force and this force opposes the motion. Rolling friction is much smaller than sliding friction. Finally, when a solid is moving in fluid (liquid or gas), there is a force opposing the motion of the solid. This force is not called friction but viscosity.



Types of Friction Force:

Static Friction:

Static means stationary, so an object will stay in-place until it experiences a great enough force to overcome the static friction force (which is the coefficient of static friction multiplied by the normal force). The coefficient of static friction depends on the surface the object is resting upon, and the normal force is the electromagnetic force that keeps all of us from falling into the hot, melting core of the Earth!

Sliding Friction:

The friction force acting between two relatively sliding and is measured as the force required to ***just*** move the body over the other. As per the name suggests, this friction arises when the object slides over the surface. This friction is weak in strength from static friction. You can easily slide the heavy objects from one position to another. Do you know that without sliding friction you won't be able to write on paper? The tip of the pencil slides over the surface and allows you to write perfectly. Another notable example is the braking system in the bikes. It is the sliding friction between the brake pads and the bike rim which slows down your bike.

Fluid Friction:

Viscosity is also known as fluid friction. Viscosity is defined as the resistance offered by liquids to motion. It arises from the internal resistance between layers of moving fluid. A viscous liquid is one which moves slowly example honey, glycerin, tar and others. The viscosity of a liquid determines the terminal velocity of objects moving through them. The effect of viscosity is taking into consideration in the design of ships, submarine, aircraft and other vehicles to reduce energy wasting to a minimum when these bodies pass through fluids.

Rolling Friction:

It is the force resisting the motion of a rolling ball or wheel (a curved surface). This type of friction is typically a combination of several friction forces at the point of contact between the wheel and the ground or other surfaces. It is the weakest type of friction (compared to static and sliding friction). This is the reason that wheels and ball bearings facilitate motion.

Question Eighteen

How a hydraulic jack works?

A hydraulic jack is a small device which can lift heavy loads with very little effort by the jack operator. It works on the lever principle. If we place a lever under a heavy object we can lift it by racing the free end of the lever.

The distance the object is lifted can be a few inches but the free end of the lever has to travel much more distance than that and that is a ratio of multiplication of the force if we move a lever times the distance it will lift the object.

We can lift pounds with an effort equivalent to pounds thus we will have to move the lever inches for every inch of lifting. One drawback is that the free end of the lever is limited as to the distance it can travel so the object cannot be lifted very far from the ground. The way to solve that problem is by using a mechanism which allows swinging of the free end of the lever without the object going down again if we can swing the lever several times we can lift the object for a practical distance.

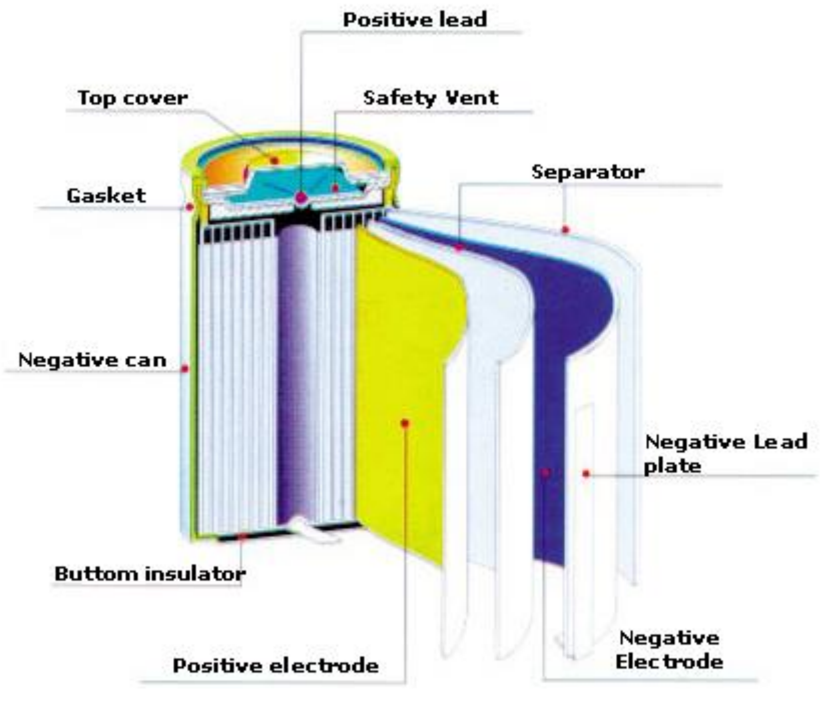
Question Nineteen

How are lithium batteries made?

Lithium batteries or simply LIB have revolutionized the electronic world with its discovery and advancement. Their increasing popularity can be seen among home-based electronic devices, electronic vehicles and even at military and aerospace applications. A lithium battery is a successful replacement to the large and heavy lead-acid batteries which were harmful to the environment. The concept behind the Lithium batteries is quite simple but still, it took decades of research to develop its technology. Today, featuring from cylindrical cells to the big batteries all are formulated with Lithium ions.

Manufacturing Process of Lithium batteries

The anode and cathode in the Lithium batteries are of the same form and act as a current collector and conducts the current in and out of the cell. The material of anode is Carbon based and the cathode is a Lithium metal oxide. They are delivered as a black powder and are stored with great care.

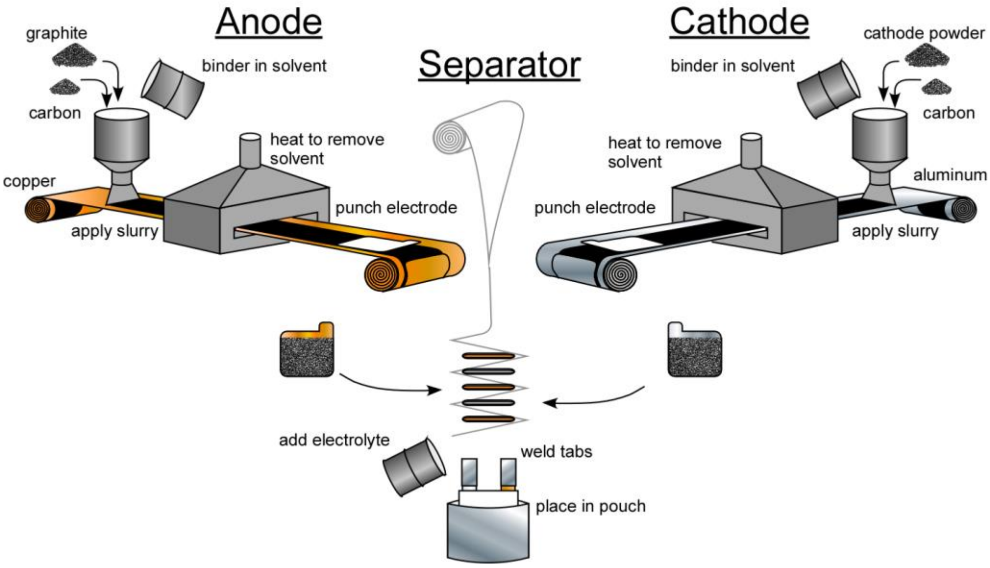


Now the metal electrode foils are delivered in large reels nearly 500mm wide. Here copper is used for anode and aluminium for the cathode and these reels are carefully mounted on the coating machine. Here the foil is unreeled and fed to the machine through precision rollers. The thickness of the coating layers must be set to allow the energy storage per unit area of the anode and cathode electrodes to be matched.

From the coater, the coated foil is fed directly into a long drying oven in order to bake the electrode material onto the foil and is further re-reeled. The foils are cut into desired lengths without burrs which can lead to internal short circuits.

The Cell Assembly

In the leading manufacturing companies of lithium batteries, automated equipment is used for cell assembly, but manual assembly methods are used by smaller units. In the first stage, the separator is sandwiched between the anode and cathode. There are two basic structures depending on the cell casing to be used. Stacked structure for the prismatic cells and spiral structure for the cylindrical cells



Prismatic cells

These are basically high capacity lithium batteries and in its design, a stacked electrode structure is used where anode and cathode foils are cut into individual plates, stacked alternately and kept apart from the separator.

Cylindrical cells

In this structure, the anode and cathode foils are formed in long strips, wound upon a cylindrical mandrel, with a separator that parts them and forms a jelly roll.

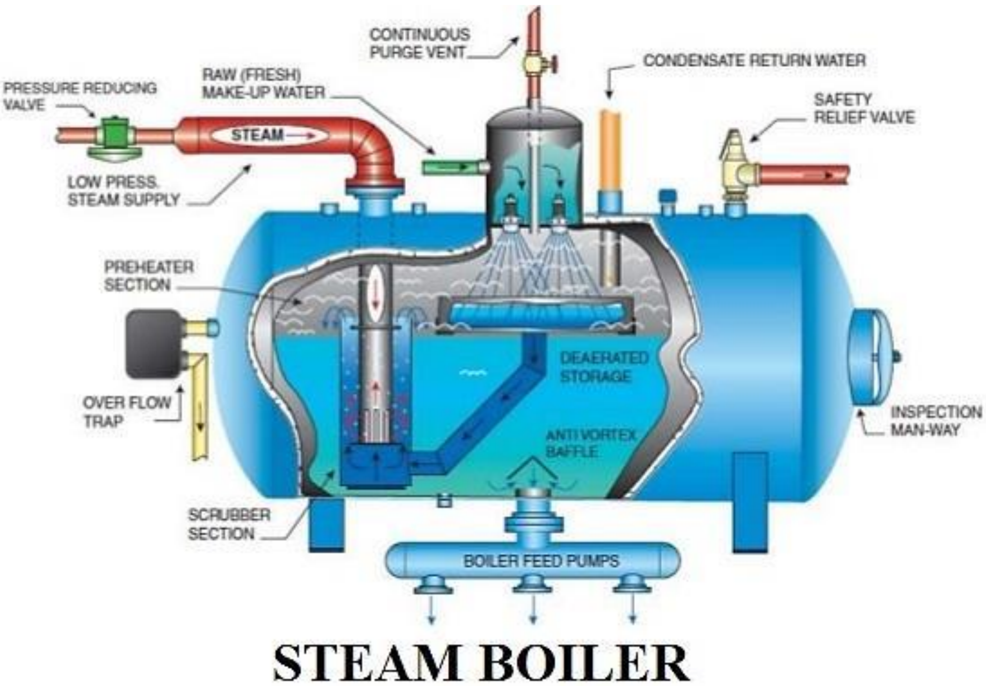
Question Twenty

How Boiler Works?

A boiler can be defined as a closed vessel in which steam is produced from water by combustion of fuel. A boiler is used in many industries such as in steam power generation, in sugar industries, in textile industries for sizing and bleaching etc. and in many other chemical industries. Earlier it was mainly used in generating power in the steam engine.

A boiler is simply an enclosed vessel which boils water and ultimately turns it into steam which is used for heating of rooms and heavy fuel oils on the ships.

The boilers are fitted with different safeties as the steam pressure is up to 8 bars in most cases. There are normally two kinds of boilers on ships, Auxiliary and Exhaust, some ships have composite boilers.



Boiler are of two types:

1. STB (Smoke tube Boiler) or donkey boiler
2. WTB (Water tube Boiler) or High-pressure boiler

On board a vessel, STB or WTB may be used as per the requirement.

Stages of Combustion:

Since a boiler operates through fuel combustion, heat transfer and energy release, the stages of combustion are typically described as follows:

1. Standby: boiler is ready to meet demand.
2. Call for Heat: system pressure or temperature has fallen below a pre-determined set point.
3. Safety Check: A series of self-tests are performed to ensure the boiler is safe to operate (water level, gas pressure, electrical status, etc.).
4. Pre-purge: a forced draft fan or blower is used to force air through the furnace or combustion chambers to remove any potential unburned fuel that might be present.
5. Pilot Ignition: fuel and air are mixed and forced through a small pilot flame tube where a spark is generated to ignite the fuel.
6. Pilot Flame Trial: a flame sensor is used to make sure a strong, sustainable flame has been developed.
7. Main Ignition: Fuel and air are mixed and forced through a burner nozzle and are ignited by the pilot flame. Main combustion continues at various rates – low to high fire – until the system set point pressure or temperature is met.
8. Post Purge – the forced draft fan or blower is run to remove any potential unburned fuel from the furnace or combustion chamber.
9. Boiler goes into standby mode until temperature or pressure falls below the set point.

WORKING PRINCIPLE OF BOILER:

The basic **working principle of boiler** is very simple and easy to understand. The boiler is essentially a closed vessel inside which water is stored. Fuel (generally coal) is bunt in a furnace and hot gasses are produced. These hot gasses come in contact with water vessel where the heat of these hot gases transfer to the water and consequently steam is produced in the boiler. Then this steam is piped to the turbine of thermal power plant. There are many different types of boiler utilized for different purposes like running a production unit, sanitizing some area, sterilizing equipment, to warm up the surroundings etc.

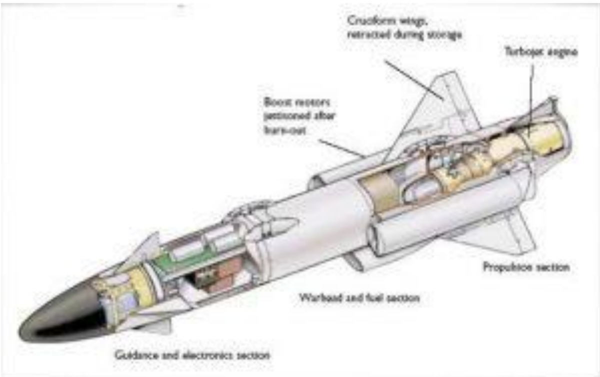
Question Twenty One

How do missiles work?

Targeting, Guidance & Propulsion

All of us has seen war footages and Hollywood war movies where a missile bound air strike saves the day. We have also heard of rockets something which seems to be just like a missile but actually isn’t. Although beyond the scope of this write-up but still we will make a small mention of rockets.

By definition, A missile is a self-propelled vehicle which uses a guiding system to guide it to its location. The basic difference between a missile and rocket is its guidance system. A rocket has no guidance and relies on pre-fed coordinates to hit its target. Missiles were first developed by German Nazis and were simple devices guided by radio waves. The missile technology has come a far way since then.



Missile Diagram

Missiles are generally categorized on the basis of its launch platform. Missiles can be air to surface, surface to surface and air to air depending on the nature of the application and need. Some missiles can even be launched from underneath a sea where a submarine acts as the launch platform.

Guidance and Targeting in missiles:

Modern missiles are a complex piece of machinery, they make use of sophisticated computer algorithms and external guidance technology to reach their targets. Guidance and targeting for modern missile systems go hand in hand as both are essentially required in order to make the hit a success. Missiles are really expensive pieces of equipment hence the guidance and targeting systems on them has to be flawless and perfect.

A missile might use simple fixed GPS coordinates as sent back by a ground team near the target and responsible for marking the target and then the same is fed into the missiles computers which in turn decides the flight path of the missile.

The missiles might even use a real-time GPS guided guidance and targeting system to hit their target. These systems would use a mix of GPS, Radar, IR, lasers & radio waves for real-time flight assistance and target acquisition. Such systems widely find their use in cruise missiles and ICBM or intercontinental ballistic missile systems.

Their mode of functions relies on one basic GPS location of the target, then this location is fed on the launch platform and missile guidance system.

To make the targeting more precise, a ground team near the target or an aircraft flying above the target will lace and mark the target with a laser which is visible to the missile systems and acts as confirmation of the target to be hit. This is the basic system for hitting the ground targets which might be stationary like a building. For moving targets, the missiles rely either on heat signature of the vehicle in question which can be tracked by the IR sensors on the missile or by having a real-time radar lock on the moving target.

Ground Laser System

When firing a missile for air to air assault the missiles would most probably rely on IR heat tracking and lock. In this case, the heat generated by the aircraft thrusters are used to lock on. This happens when both the air crafts in combat are in proximity to each other. In case the distance between the firing platform and the target is more than a mix of radar guidance and IR lock might be used to hit the target.

In-flight course corrections and change of directions, as well as maneuverability of missiles, are done by a process called thrust vectoring. In thrust vectoring the propulsion jets change the direction of thrust for changing the course of the missile. Apart from changing the vector primary thruster, the missile has some additional thrust equipment designed especially for course corrections.

Propulsion systems:

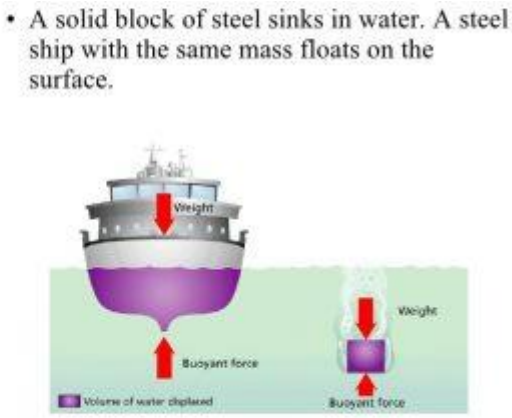
The missiles owing to the nature of their utility have to gain great speeds in the least time possible, this calls for having a propulsion system which is both heavy duty and powerful. Missiles run on dry fuel and wet fuels in general but might have a mix of both depending upon the desired range and application.

Missiles may have a single stage engine for short range applications and multi-stage for a long-range purpose. A mix of rocket engine for initial speed and acceleration and a jet engine for maintenance of flight may also be used in some types of missiles. Thrust vectoring may be present in more sophisticated missile systems.

Question Twenty Two

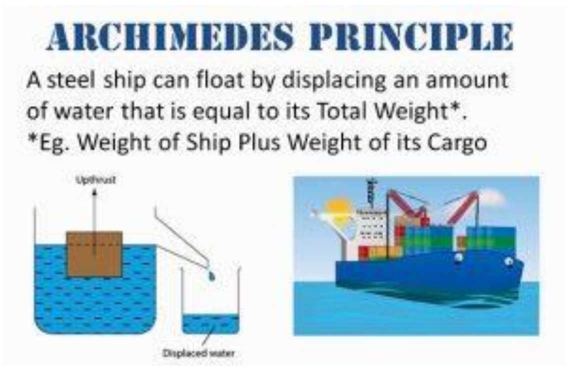
How do Ships Float?

Now, this is the question which everyone must have pondered over as a kid. Why something so heavy does not sink but floats, and not only floats but also carries so much cargo at times. Well, today we will understand why ships float. Now, everything in this world is ruled by classical physics and so does this phenomenon



Before we jump on to the science and math of why ships float we have to pay some due respect to the guy because of which we have the answer to this curious question. That guy is **Archimedes**, Archimedes was a scientist and much more. He was a genius and some people even regarded him as being mentally retarded.

The legend has it that he was given a task by the king to adjudge whether his crown was made up of pure gold or not. Now Archimedes was having a bath in his bathtub and also pondering over the task at hand. Nobody knows what happened but somehow the movement of water in his bathtub led him to formulate the Archimedes principle.

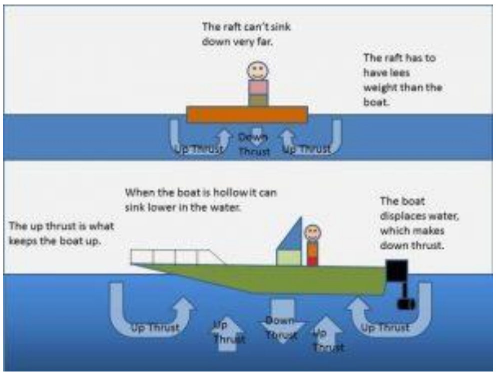


Archimedes Principle

Archimedes principle states that **“The upward buoyant force that is exerted on a body immersed in a fluid, whether fully or partially submerged, is equal to the weight of the fluid that the body displaces”**

So how does it fit into this equation or our question that “why ships float?”, see its quite evident that when the weight of the body is less than the weight of the fluid it displaces, then that object will float and not sink. The game is off the volume vis weight.

For example: let us take an object which has a volume of say 10 cubic meters and weighs 20 metric tons. Put it straight in the water and see what will happen. Naturally, it will sink as the amount of water displaced will be far more than the volume of the object.



Now, let’s increase the volume of the object to say 20 cubic meters keeping the weight same, again let’s throw it in water, what will happen now is that the object will neither sink nor float. Reason is that the amount of water displaced here is equal to the volume of the object. Now let’s assume we increase the volume of the object to say 30 cubic meters keeping the weight same, now we have an object that is floating in the water due to the obvious reasons.

Same happens in case of a ship, the design of the ship is made in such a way that the amount of water it displaces is always more than its weight. Hence the ships float on water. Modern ships have buoyancy control mechanism which makes adjustments according to the laden weight of the ship.

So, this was the answer to your curious question folks.

Question Twenty-Three

How do trains turn without differential?

This is a question that would baffle many. It surely baffled us and we thought the flanges on the wheels keep the trains on the track, but that's not the case at all. Then what could it be? Let's try to address that exactly.

If you notice the shape of the wheel of a train, you will notice that they are conical in shape. The side with greater diameter is on the inside. The shorter diameter lies towards outside. When the train approaches a curve, and has to turn then the wheels slide away in the correct direction. This keeps the train on the track and allows for proper negotiation of the curve.

The following takes place once a train is in motion:

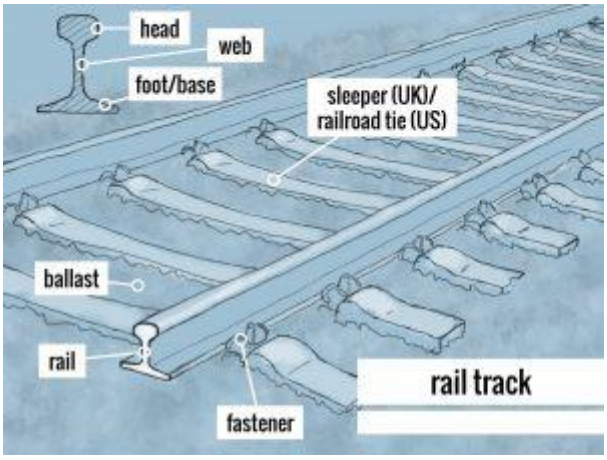
In studying this theory, we are considering that the train is moving in the left direction. Now if the train is making a left turn. Then the wheels due to centrifugal force will move towards the right. Obviously, this will result in an increase in diameter of the right wheel and decrease in diameter of the left wheel.

This will allow the right wheel to travel more distance due to the larger diameter when compared to the left wheel. Hence solving the problem. The simple design provides a genius solution every time.

The beauty of the whole system is that the wheel shift happens automatically. No external system is required for the same.

Additional Information on Rail Wheel:

Now we know how trains turn without a differential. Let us also garner some information on the locomotive wheel.



Railway Track

A locomotive wheel consists of two parts:

- Wheel.
- Tire.

The Tire is the outer surface which remains in contact with the track. A Tire is fitted on the wheel to reduce maintenance costs. Replacing a worn-out wheel is very expensive. Hence a replaceable steel layer called tire is used. The tire is forged on the wheel and wears over the use.

The most common cause of wheel or tire damage in trains is heavy breaking. The entire brakeforce is directed towards wheels. This puts a heavy burden on them and damages them. If the damage is severe then wheel has to be replaced. Train tires are about 3 inches in thickness making them durable. The replacement also calls for replenishing the worn inches. Hence making maintenance reasonable.

Question Twenty Four

How Much Current Can the Human Body Withstand?

Human body is a good conductor of electricity. When it comes to an electric shock, we all have at least one bad experience with it in our lifetime. We have heard about many incidents where a person gets electrocuted at a workplace or gets an electric shock through their household appliances.

But why is it that some people don’t get affected by an electric shock whereas others end up with being fatal? The answer is the amount of electric current that passes through their bodies.

We often see a ‘danger’ or ‘no trespassing’ symbol around generators and electric boards. These symbols warn us not to touch that equipment as they constantly work at high voltages. But do voltages really affect us or there is some other culprit?

Most of us aren’t aware of the fact that voltage doesn’t really affect us. It is the current that is forced through our body that affects us. That’s why birds sitting on electric wires aren’t electrocuted. When there is a potential difference created in a conductor, then current flows from the higher potential end to the lower potential end. This is the reason why birds don’t get electrocuted as they are at the same potential on both ends of the body as the wire. Hanging on the wire at high potential and touching the ground which is at a zero potential, creates potential difference and it renders the flow of current from higher potential to lower potential. Thus, forcing huge current to flow through us.

So, in short, humans can withstand any amount of voltage until and unless they are not creating a potential difference in their body. Now, how much current can a human body withstand?

You can get a shock from a current of 10 mA or .01 A, but it won’t be fatal. At 100 mA, muscular contraction starts but as the human heart has a low resistance, even a current of smaller magnitude like 10 mA can be deadly.

However, current never reaches the heart because our skin has more resistance than the heart and hence it absorbs the current completely. When the current magnitude is more than 1000 mA, the muscular contractions augment to a level which doesn't allow us to let go of the wire. This results in muscle paralysis and heart get ventricular fibrillation which is an uncoordinated intermittent twitching of heart ventricles that produce ineffective heartbeats. This may result in death if not aided in time.

Moreover, with a current of a magnitude of 2000 mA, there can be burn and unconsciousness. This shock makes muscular contraction so severe that heart plunges into clamps. This amount of current can lead to internal burn and clamps may result in a cardiac arrest which can cause death.

So, aren't we unaffected by the current?

The amount of current flowing through our body depends on the extent to which our body is permeable or resistant to current. Well, resistance to the current depends on our skin condition. If the skin is wet it is estimated to be 1000 ohms and for dry skin, it is 500000 ohms. This finite resistance of our body makes us non-impervious to current.

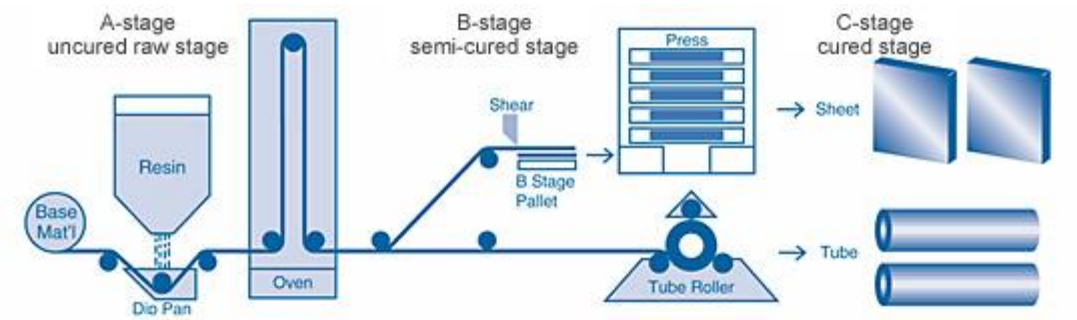
Question Twenty Five

How Plastic Is Formed and Molded

Plastic is a polymer, chains of simple organic chemicals (monomers), linked together in long chains. The monomers are synthesized in refineries, from oil. The linking of the monomers in the polymer chain is done inside polymerization reactors until the desirable average molecular weight is achieved for the polymer. Then dyes and other additives are added to the molten polymer and the material is extruded into filament, granules or flakes and cooled.

Plastics are sold in these forms as raw materials to the various manufacturers. Recycled plastic can be molten and re-extruded or directly crushed into granules or torn into flakes.

Plastic products are made out of raw plastic using a host of moulding techniques which always involve mixing and melting of the raw material inside a screw extruder.



Most plastic molecules are just hydrogen and carbon atoms, or mostly hydrogen and carbon with some oxygen, sulfur, nitrogen or chlorine atoms as well. They take advantage of the ability of carbon atoms to bond their electrons together in long flexible chains in order to create long flexible molecules.

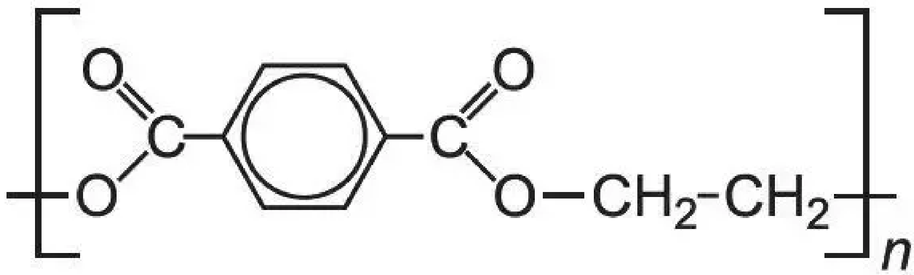
When we combine monomers, we generate polymers or plastics. The plastic production process begins by heating the hydrocarbons in a “cracking process.” The resulting resins may be molded or formed to produce several different kinds of plastic products with application in many major markets.

Processes Used in Plastic Making:

Organic substances, in chemistry, refer to substances containing carbon. Carbon has a very useful electronic configuration which allows it to bond easily with 4 atoms at once.

The basic organic molecules, alkanes, alkenes and alkynes, contain only carbon and hydrogen. However, many other ‘functional groups’, can be added to the carbon chain to change the properties of the substance. For example, oxygen, nitrogen, sulphur or chlorine. However, the vast majority of plastics do not contain the latter two.

If you aren’t familiar with the structure of organic compounds, here is an example:



The above substance is polyester. The brackets and subscript ’n’ around this diagram representing the fact that this is a single unit of polyester, which is repeated in a chain to create the full fabric. As you can see, there is only carbon, hydrogen and oxygen in polyester (the three elements most common in the human body). The overall structure is reasonably complex, with two standard methyl links, two ester groups, and an aromatic ring (benzene).

So, where do the elements and substances, that make up plastics like polyester, come from?

The answer is, of course, from fossil fuels. Crude oil, petroleum, coal, and natural gas are entirely composed of these organic substances, and plastics are made by utilizing various chemical processes, with chemicals from fossil fuels.

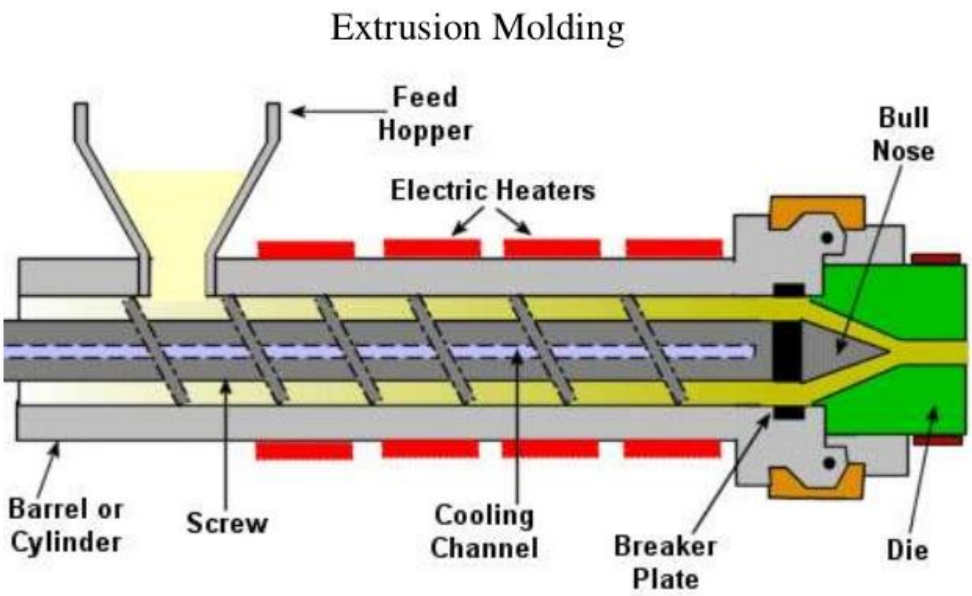
Fossil fuels, in turn, are made of dead and compressed organic matter (this time referring to things that were previously alive, like trees).

So, if you were to go way back into the history of the atoms in that pair of polyester underwear you’re wearing, they might have been part of a dinosaur, or a huge tree.

Now Enough About Plastic Making Process, let us talk about how plastic is molded into various shapes.

Plastic Molding Processes:

The main process used to form plastics. A heated plastic compound is forced continuously through a forming die made in the desired shape (like squeezing toothpaste from a tube, it produces a long, usually narrow, continuous product).



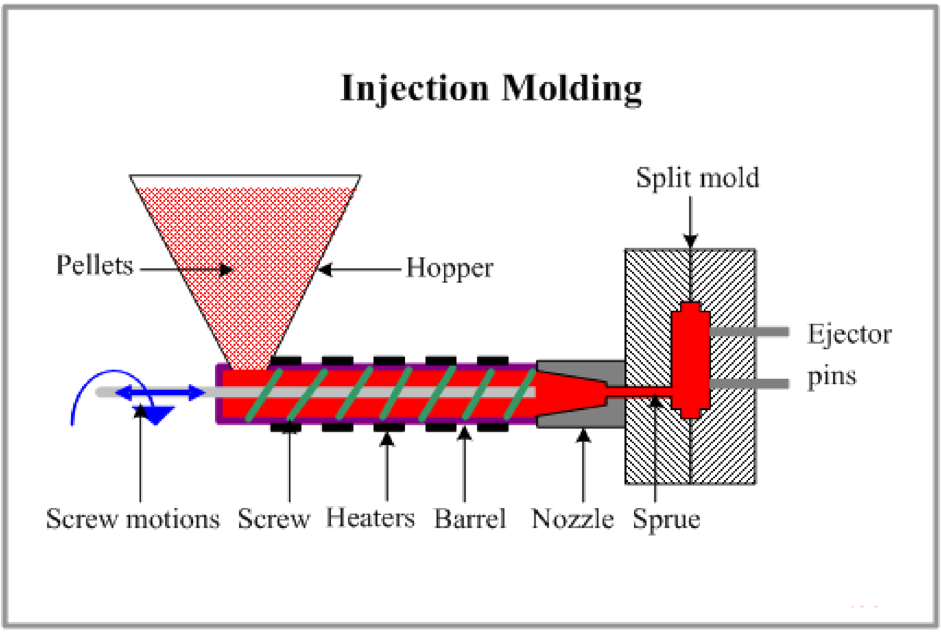
The formed plastic cools under blown air or in a water bath and hardens on a moving belt. Rods, tubes, pipes, Slinkys, and sheet and thin film (such as food wraps) are extruded then coiled or cut to desired lengths.

Plastic fibers also are made by an extrusion process. Liquid resin is squeezed through thousands of tiny holes called spinnerets to produce the fine threads from which plastic fabrics are woven.

Injection Molding:

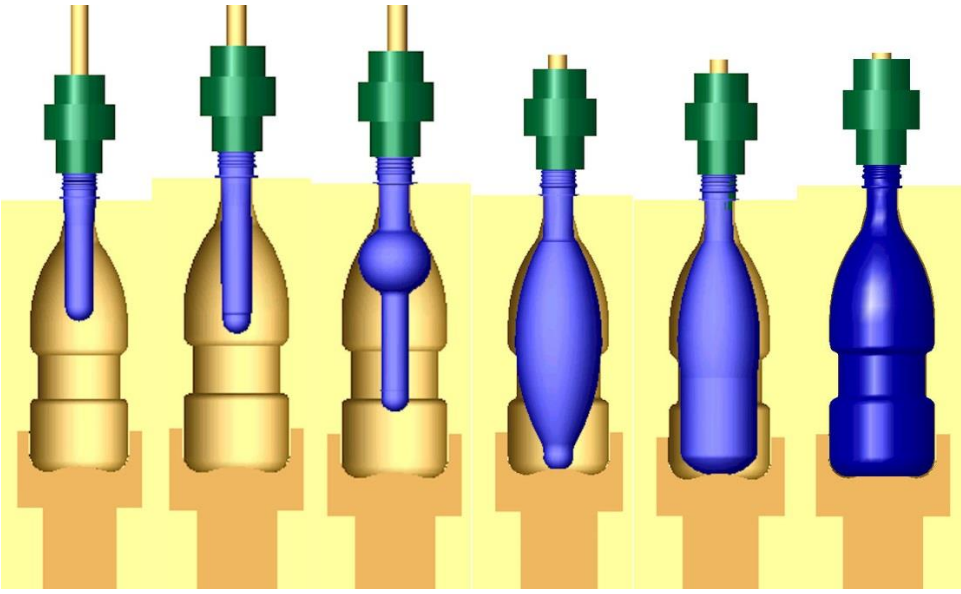
It is the second most widely used process to form plastics. The plastic compound, heated to a semifluid state, is squirted into a mold under great pressure and hardens quickly. The mold then opens and the part is released. This process can be repeated as many times as necessary and is particularly suited to mass production methods.

Injection molding is used for a wide variety of plastic products, from small cups and toys to large objects weighing 30 pounds or more.



Blow Molding:

Pressure is used to form hollow objects, such as the soda pop bottle or two-gallon milk bottle, in a direct or indirect method. In the direct blow-molding method, a partially shaped, heated plastic form is inserted into a mold. Air is blown into the form, forcing it to expand to the shape of the mold. In the indirect method, a plastic sheet or special shape is heated then clamped between a die and a cover. Air is forced between the plastic and the cover and presses the material into the shape of the die.



Question Twenty Six

Iron – Carbon Phase Diagram

In their simplest form, steels are alloys of Iron (Fe) and Carbon (C). The study of the constitution and structure of iron and steel start with the iron carbon phase diagram. It is also the basic understanding of the heat treatment of steels.

Iron Carbon phase diagram

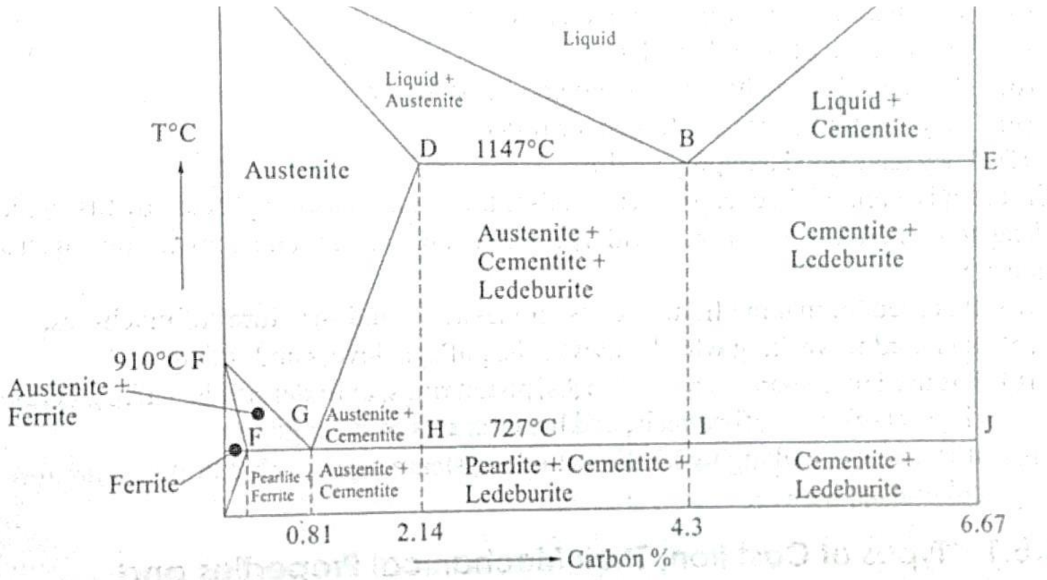


Fig. 1.1 *The Iron-carbon Diagram (Simplified)*

On this diagram, the carbon percentage is shown on the x-axis and temperature on the y-axis. This figure shows the Iron Carbon Equilibrium Diagram. In this diagram, the lines indicate the boundaries where the alloy changes its phase. The different phases or mixture of phases occur in different areas enclosed by these curves. Pure iron exists in two allotropic forms, ∝-iron, γ-iron, both in the solid state. The ∝-iron exists between 910°C, and also above 1392°C, and its crystal lattice body-centered cubic. The ∝-iron which exists above 1392°C is also called δ-iron. The γ-iron exists in the range 910°C to 1392°c, and its crystal is face-centered cubic. The melting point of iron is 1539°C.

In Fe-C system is in the solid state, the different phases which are present are Ferrite (Solid solution), Austenite, Cementite (Chemical compound iron Carbide), and free carbon in the allotropic form of graphite.

Steel is an alloy of carbon and iron and other alloying elements (e.g. Mn, Si) with carbon content up to 2% intended for wrought products or semi-products. Cast iron is an alloy of carbon and iron and other alloying elements (e.g. Mn, Si) with carbon content over 2% intended for castings. Now, we consider only a part of Fe-Fe3C diagram referring to steel. Perlite is a structure (i.e. consists of two phases) consists of alternate layers of ferrite and cementite in the proportion 87:13 by weight. Perlite is formed from austenite at the eutectoid temperature (A1) 727°C upon slow cooling. There are three groups of steels according to carbon content: – hypereutectoid steels containing less than 0.76% C – eutectoid steel with carbon content about 0.76% – hypereutectoid steels contain more than 0.76% C (up to 2% C).

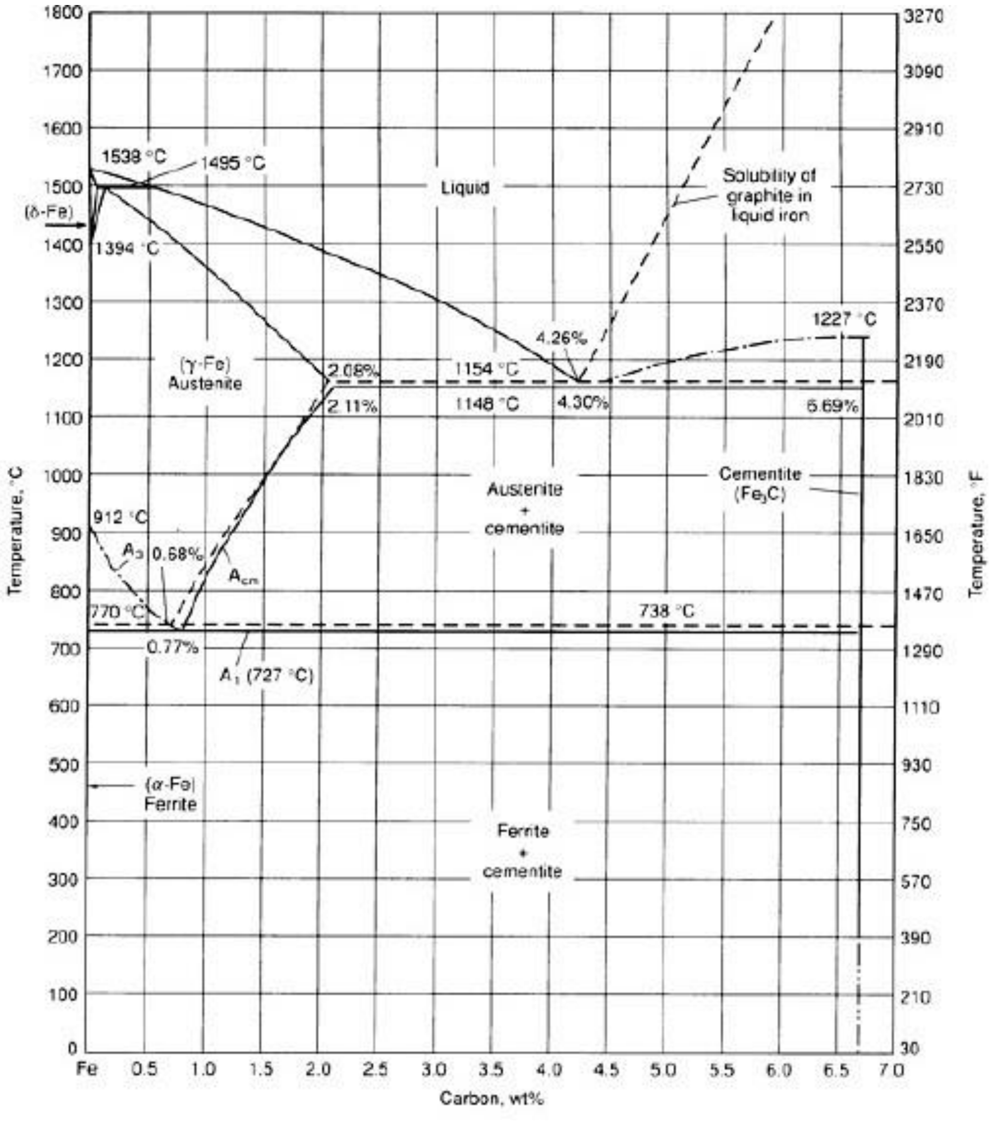
The austenite-ferrite transformation:

Under equilibrium conditions, pro-eutectoid ferrite will form in iron-carbon alloys containing up to 0.8 percent carbon. The reaction occurs at 910 Deg. C in pure iron, but takes place between 910 Deg. C and 723 Deg. C in iron-carbon alloys. However, by quenching from the austenitic state to temperatures below the eutectoid temperature Ae1, ferrite can be formed down to temperatures as low as 600 Deg. C. There are pronounced morphological changes as the transformation temperature is lowered, which it should be emphasized apply in general to hypo-and hyper-eutectoid phases, although in each case there will be variations due to the precise crystallography of the phases involved. For example, the same principles apply to the formation of cementite from austenite, but it is not difficult to distinguish ferrite from cementite morphologically.

The austenite-cementite transformation

The Dube classification applies equally well to the various morphologies of cementite formed at progressively lower transformation temperatures. The initial development of grain boundary allotriomorphs is very similar to that of ferrite, and the growth of side plates or Widman Staten cementite follows the same pattern. The cementite plates are more rigorously crystallographic in form, despite the fact that the orientation relationship with austenite is a more complex one. As in the case of ferrite, most of the side plates originate from grain boundary allotriomorphs, but in the cementite reaction more side plates nucleate at twin boundaries in austenite.

Iron Carbon phase diagram



The austenite-pearlite reaction:

Pearlite is the most familiar microstructural feature in the whole science of metallography. It was discovered by Sorby over a century ago, who correctly assumed it to be a lamellar mixture of iron and iron carbide.

Pearlite is a very common constituent of a wide variety of steels, where it provides a substantial contribution to strength. Lamellar eutectoid structures of this type are widespread in metallurgy, and frequently pearlite is used as a generic term to describe them.

These structures have much in common with the cellular precipitation reactions. Both types of reaction occur by nucleation and growth, and are, therefore, diffusion controlled. Pearlite nuclei occur on austenite grain boundaries, but it is clear that they can also be associated with both pro-eutectoid ferrite and cementite. In commercial steels, pearlite nodules can nucleate on inclusions.

It may be seen that the normal Iron-carbon equilibrium diagram represents the metastable equilibrium between iron and iron carbide. Cementite is metastable as the true equilibrium is between iron and graphite. Although graphite occurs extensively in cast irons (2 to 4 wt percent carbon), it is usually difficult to obtain this equilibrium phase in steel (0.03 to1.5 wt percent carbon). Therefore, the metastable equilibrium between iron and iron carbide is normally considered, since it is relevant to the behavior of a variety of steels in practice.

On comparing austenite (? -iron) with ferrite (? -iron) it is noticed that solubility of carbon is more in austenite with a maximum value of just over 2 wt percent at 1147 Deg. C. This high solubility of carbon in austenite is extremely important in heat treatment when solution treatment in the austenite followed by rapid quenching to room temperature allows the formation of a supersaturated solid solution of carbon in iron.

The ferrite phase is restricted with a maximum carbon solubility of 0.02 wt percent at 723 Deg. C. Since the carbon range available in common steels is from 0.05 to 1.5 wt percent, ferrite is normally associated with cementite in one or other form. Similarly, the? -phase is very restricted and is in the temperature range between 1390 and 1534 Deg. C and disappears completely when the carbon content reaches 0.5 wt percent.

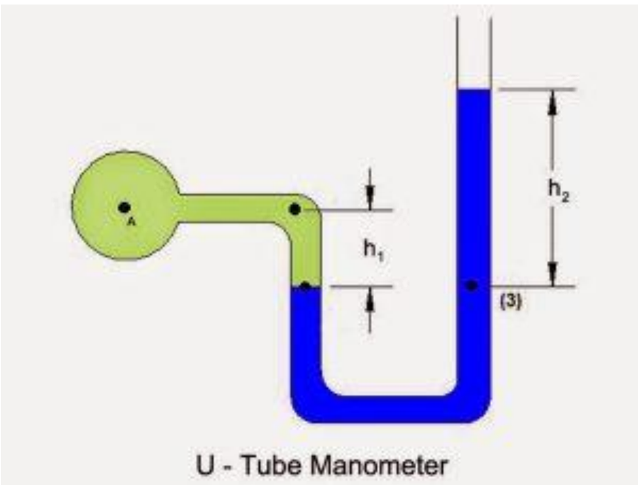
Question Twenty Seven

Manometer & Its Types

A Manometer by definition is a device used for measuring the pressure of a fluid by balancing it against a pre-determined column of fluid. The most common type of manometer which almost all of us might have seen is sphygmomanometer. It is the device which doctors use to measure your blood pressure.
A manometer is can be used at any applicative process where the pressure of a fluid needs to be measured.

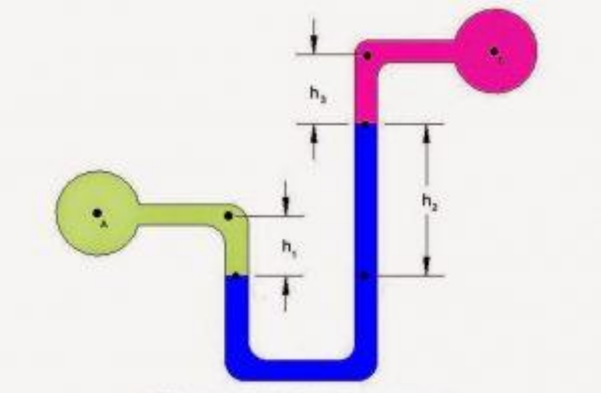
The five basic types of manometers are:

1. U-Tube Manometer:



This type of manometer is U shaped, with one end open to atmosphere. It is used for measuring suction. It has the capability of measuring both positive and negative suction pressures. It utilizes the principle of specific gravities for measuring the suction pressure. This type of manometer generally has a liquid whose specific gravity is greater than that of the fluid whose suction pressure is to be measured.

2. Differential U-Tube Manometer:



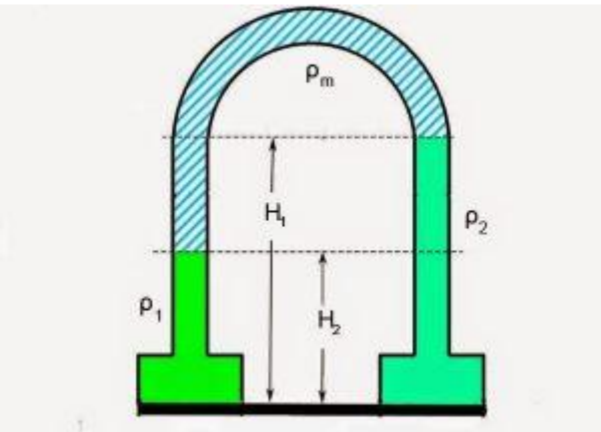
Differential U - Tube Manometer

This type of manometer is slightly different from the normal U Tube manometer. Here the open end is also closed, what that means is both the ends of this type of manometer are closed. It really becomes a tool of importance where the pressure is to be measured directly. This manometer type has fluid or liquid filled at different pressures on both ends.

The equation for this is as follows:

3. Inverted U – Tube manometer:

This type of manometer as the name suggests has an inverted U-shaped tube. It is used to measure differences in low pressure between two points, where the high level of accuracy is desired. It is filled with liquid on the ends. The space between liquids is filled with air. This air can be expelled or admitted into the apparatus using a tap. This is done to adjust the pressure difference to obtain an accurate reading.



Inverted U tube Manometer

The equation for the same (source: http://www.msubbu.in/ln/fm/Unit-I/InvertedUtubeMano.htm)

Equating the pressure at the level XX'(pressure at the same level in a continuous body of static fluid is equal),

On the left-hand side:

$P_x = P_1 – rg(h+a)$

On the right-hand side:

$P_{x'} = P_2 – (rga + r_m gh)$

Since $P_x = P_{x'}$

$P_1 – rg(h+a) = P_2 – (rga + r_m gh)$

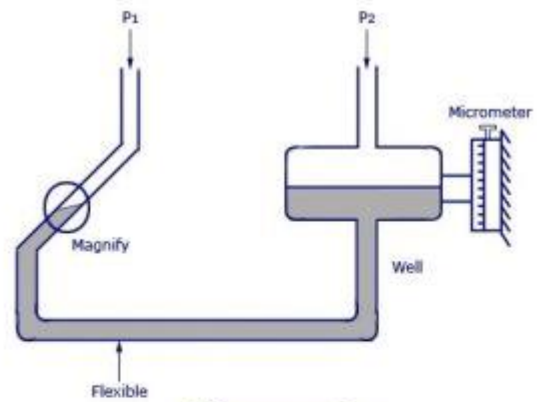
$P_1 – P_2 = (r – r_m)gh$

If the manometric fluid is chosen in such a way that $r_m << r$ then,

$P_1 – P_2 = rgh$.

4. Micro Manometer:

Micromanometer is a great tool used in fluid statics. It is a modified form of a simple manometer. It has one limb which is larger in cross-section. It is a device which is used to measure very minute pressure differences with high accuracy.



Micromanometer

The equation of hydrostatic equilibrium at PQ can be written as

$$p_1 + \rho_w g(h + \Delta z) + \rho_G g\left(z - \Delta z + \frac{y}{2}\right) = p_2 + \rho_w g(h - \Delta z) + \rho_G g\left(z + \Delta z - \frac{y}{2}\right) + \rho_m gy$$

where ρ_w, ρ_G and ρ_m are the densities of working fluid, gauge liquid, and manometric liquid respectively.

From continuity of gauge liquid,

$$A\Delta z = \alpha \frac{y}{2}$$

$$p_1 - p_2 = gy\left[\rho_m - \rho_G\left(1 - \frac{\alpha}{A}\right) - \rho_w \frac{\alpha}{A}\right]$$

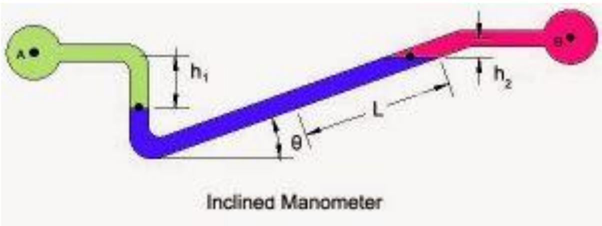
If a is very small compared to A

$$p_1 - p_2 \approx (\rho_m - \rho_G) gy$$

With a suitable choice for the manometric and gauge liquids so that their densities are close a $(\rho_m \approx \rho_G)$ reasonable value of y may be achieved for a small pressure difference.

5. Inclined Manometer:

This a high precision and high accuracy type of manometer. It is used to measure the minuscule amount of pressures with high accuracy. Its configuration is inclined and this makes it more accurate than other types of manometers. It is used where manometric properties of liquids are very close.



If the manometer, instead of being vertical, is set at an angle θ to the horizontal, then a pressure difference corresponding to a vertical difference of levels x gives a movement of the meniscus s = x/sinq along the slope.

If θ is small, a considerable magnification of the movement of the meniscus may be achieved.

Angles less than 5^0 are not usually satisfactory because it becomes difficult to determine the exact position of the meniscus. One limb is usually made very much greater in cross-section than the other. When a pressure difference is applied across the manometer, the movement of the liquid surface in the wider limb is practically negligible compared to that occurring in the narrower limb. If the level of the surface in the wider limb is assumed constant, the displacement of the meniscus in the narrower limb needs only to be measured, and therefore only this limb is required to be transparent.

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