The Engineering Materials are mainly classified as

1. Metals and their alloys, Such as iron, Steel, copper, Aluminium etc

2. Non-metals, Such as glass, rubber, plastic etc.

The metals may further be Classified as

a) Ferrous metals and
b) Non- ferrous metals.

The Ferrous metals are those which have the iron as their main Constituent, Such as iron Steel.

The Non-ferrous metals are those which have a metal other than iron as their main Constituents, Such as Copper, Aluminium, brass etc.

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The important mechanical properties of metal are as follo

1. Strength - It is the ability of a materials to resist the externally applied force without breaking or yielding.

2. Stiffness - It is the ability of a material to resist deformation under Stress. The Modulus of elasticity is the measure of Stiffness.

3. Elasticity - It is the property of the material to regain its original shape after deformation when the External force is removed.

4. Plasticity - It is the property of a material which retains the deformation produced under load permanently.

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5) Ductility - It is the property of a material enabling it to be drawn into wire with the application of a tensile force

6. Toughness.- It is property of the material to resist fracture due to high impact loads like hammer blows

7. Resilience - It is the property of the materials to absorb energy and to resist shock and impact loads.

8. Creep - when a part is Subjected to Constant Stress at high temperature for a long period of time it will go slow and permanent deformation Called Creep. Design I.C engine, Boilers, turbines.

9. Fatigue - when a materials is Subjected to repeated Stresses it fails at Stresses below the yield point Stresses. Such type of failure of Material is known as fatigue.

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Pig Iron.

It is the crude form of iron and is used as a raw material for the production of various other ferrous metals, such as cast iron, wrought iron, and steel.

The pig iron is obtained by smelting iron ores in a blast furnace.

Iron ores

- As oxides
  1) Haematite (Fe_2O_3)
  2) Magnetite (Fe_3O_4)
  3) Limonite ($Fe_2O_3 H_2O$)
- As Carbonates
  1) Siderite $FeCO_3$
- As Sulphide
  1) Pyrite FeS_2

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The pig Iron is obtained from the Iron ores in the following steps.

1) Concentration - It is the Process of removing the impurities like clay, Sand etc from the iron ore by washing with water

2) Calcination and roasting -
It is a process of Expelling moisture, CO_2, Sulphur & arsenic from the iron ore by heating in Shallow Kilns.

3) Smelting :- It is a process of reducing the ore with Carbon in the presence of a flux.

Cast Iron :-

The cast iron is obtained by remelting pig iron with Coke and Lime stone in a furnace known as Cupola.

Alloy of :- Iron and Carbon.
Carbon Contents in cast iron varies from 1.7 to 4.5%.

It may be present either as free Carbon (or graphite) or Combined Carbon (or Cementite).

The cast iron also contains small amounts of impurities such as

1. Silicon - It may be present in cast iron upto 4%.
   It provides the formation of free graphite which makes the iron soft and easily Machinable.

2. Sulphur → It makes hard and brittle, It must be kept below 0.1% for most foundry purposes

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3. Manganese - white and hard. Kept below 0.75%.

4. Phosphorus -

Types of Cast Iron :-

a) Grey Cast Iron - (FG).
It is an ordinary Commercial iron having 3 to 3.5% Carbon. Carbon is present in the form of free graphite.

* Low Tensile Strength.
* high Compressive Strength
* No ductility

It can be easily Machined.

b) White Cast Iron - It is a particular Variety of cast iron having 1.75 to 2.3% carbon.

* high tensile Strength
* low Comp Strength.

c) Chilled Cast Iron
d) Mottled Cast Iron :-
e) Malleable Cast Iron —
(WM, BM, PM).

It is obtained from white cast Iron by a suitable heat treatment process (i.e Annealing).

f) Nodular or Spheroidal graphite Cast Iron — (SG).

G) <u>Alloy Cast Iron</u> :-

It is produced by adding alloying elements like

1) Nickel
2) Chromium
3) Molybdenum
4) Copper and
5) Vanadium

Special properties of alloy Cast Iron

1) increased Strength
2) high wear resistance
3) Corrosion resistance or heat resistance

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wrought Iron :-

It is the purest form of Iron ~~Carbon~~ Contains 99.8% Iron.
The Carbon Contaoint 0.02%.
It is a tough, Malleable and ductile Material.

Steel :- It is an alloy of Iron and Carbon with carbon Content upto a maximum of 1.5%.

1) Dead mild Steel :- upto 0.15% Carbon

2) Low Carbon or mild Steel :- upto 0.15% to 0.45% Carbon.
3) Medium Carbon Steel upto 0.45% to 0.8%.
4) High Carbon Steel 0.8 to 1.5%.

The principal methods of Manufactoring Steel are as follows :-

1) Bessemer process.

2) Open hearth process –
(Siemens – Martin process)
large quantity of Mild Steel with definite quality and composition, is required.

3) Duplex process –
Combination of acidic bessemer process & basic open hearth process.

4) L-D process (Lenz – Donawitz)

* Elements of Alloys Steel :-

1) Nickel – The steel containing 2 to 5% nickel improves tensile strength, raises elastic limit, imparts hardness, toughness and reduces rust formation.

* Nickel alloy steel containing 36% nickel is known as Invar.
* It has nearly zero coefficient of expansion. So it is widely used for making pendulums of clocks, precision measuring instruments etc.

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2. Chromium –
i) Addition of chromium to Steel increases Strength, hardness and Corrosion resistance.
ii) A chrome Steel Containing 0.5 to 2% Chromium is used for balls, rollers and races for bearing dies etc.

(iii) Steel Containing 3.25% nickel, 1.5% Chromium and 0.25% Carbon is known as nickel - chrome Steel.

3. Vanadium –: It is added in low and Medium Carbon Steels in order to increase their yield and tensile Strength properties.

It is used for making high Speed tool steels, Crankshafts etc.

4. Tungsten –
i) Steel Containing 18% tungsten, 4% Chromium, 1% Vanadium and 0.7% Carbon is called as tool Steel or high Speed Steel.

(ii) It is used for making high Speed Cutting tools Such as

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cutters, drills, dies, reamers etc.

5. Manganese - It is added to Steel in order to reduce the formation of Iron Sulphide by Combining with Sulphur.
Steel Containing manganeses varying from 10 to 14% and Carbon from 1 to 1.3% form an alloy Steel which is Extremely hard and tough.

It is used for railway Equipment rock Crushing, mining.

6. Silicon - It increases the Strength and hardness of Steel without lowering its ductility.

Silicon Steel Contains 1 to 2% Silicon and 0.1 to 0.4% Carbon have good magnetic permeability.
used for making transformer and generator in the form of laminated Cores.

7. Cobalt :- 1 to 12 %. red hardness by retention of hard Carbides at high temperature.

8. Molybdenum :-

Stainless Steel :-

Steel which when correctly heated treated and finished, resists Oxidation and Corrosive attack from most Corrosive media.

1) Martensitic Stainless Steel	Ferritic Stainless Steel	Austenitic Stainless Steel (18/8 Steel)
* 12 to 14 % Chromium and 0.12 to 0.35 % Carbon is called Martensitic Stainless Steel. as they possess ~~Magnetic~~ Martensitic Structure	* Chromium upto 16 % to 18 % and 0.12 % Carbon are called ferritic Stainless Steel	18 % Chromium and 8 % nickel

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Structure of Solid

Amorphous Solid	Crystalline
Arranged chaotically i.e. atoms are not arranged in a systematic order	Atoms making up the crystals arrange themselves in a definite & orderly manner and form.

Eg wood, plastic

A/c to Bravais (a scientist) there are fourteen possible types of space lattices, But following are the usually three types.

1) Body Centred Cubic (B.C.C)

i) 9 atoms - 8 faces (corner), 1 centre

This type of lattice are found in α-iron, tungsten, Chromium, manganese, Molybdenum. etc.

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2. Face Centred Cubic (F.C.C)
Space lattice.

* 14 atoms. → 8 Corner + 6 Centre of Six faces.
* found in (Gamma γ - Iron).
Al, Cu, Pb, Ni, Ag

3. Closed packed Hexagonal.

* 17 atoms → 12 atoms at 12 Corners + one atom at the Centre of each of the two hexagonal faces + 3 atoms Symmetrically arranged in the body of the cell.

Allotropic forms of pure Iron:-
pure Iron Exists in three allotropic forms

a) Alpha (α) iron	γ-Iron Gamma Iron	δ-Iron Delta Iron
* It Exists between room temp to 910°C.	* It Exists 910°C to 1404°C.	* 1404°C to 1539°C
* B.C.C Structure	* F.C.C Structure	* B.C.C Structure
* ferro magnetic	*	*

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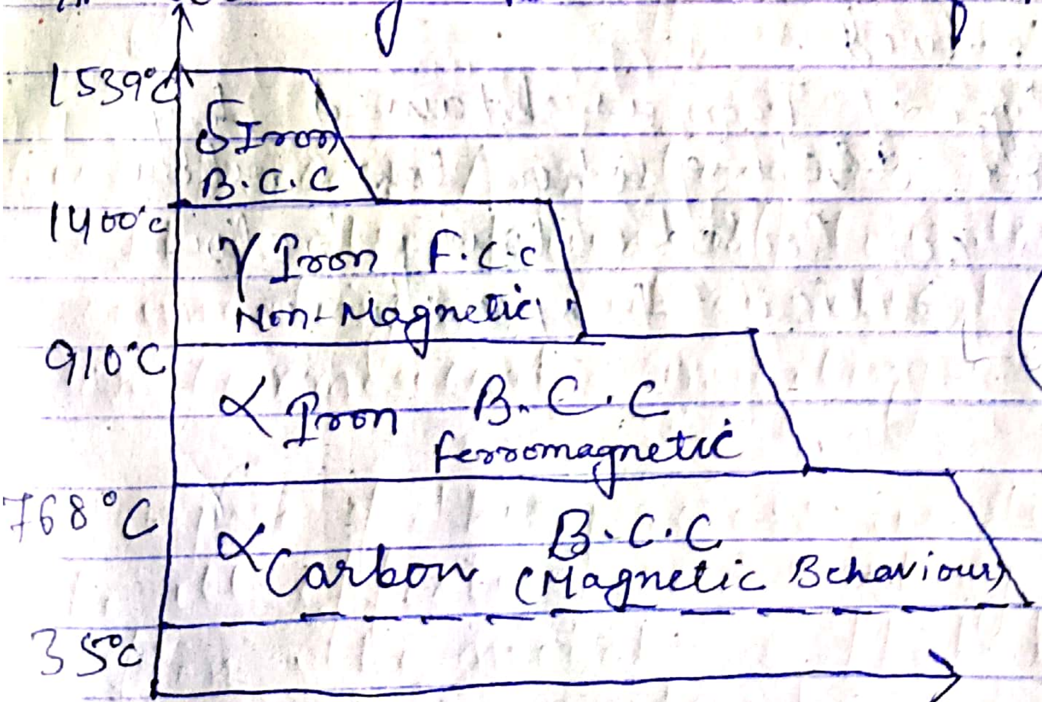
Annealing → Recovery → Recrystalliza-
↓
Grain growth.

Micro Structure
↓
Atomic arrangement.
Grain Structure
(>100x)
↓
Material properties
↓
Changes
↓
Atomic arrangement
↓
Heating and cooling process.

Macro Structure
<100 x
Naked

* Cooling Behaviour of Pure Iron



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Principal micro-Constituents of an Iron-Carbon System.

1) Austenite - The Solid Solution of ferrite and iron Carbide in gamma Iron is known as Austenite.

Solid Solⁿ is formed in Steels Carrying Carbon to a maximum of 1.8% at 1130°c.

It is Soft and Non-magnetic Substance.

when it is Cooled below 723°c it Changes into pearlite and ferrite.

2) Ferrite - It is a BCC phase of Iron in which only a very limited amount of ~~Cal~~ Carbon Can be dissolved.

This type of Iron is obtained ~~by~~ ~~Slow~~ ~~cooling~~ when low Carbon Steel is Cooled Slowly below the Critical temperature.

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3. Cementite -
It is present in steel carrying above 0.8% Carbon.

4. Ledeburite - 1130°C and carries 4.3% Carbon.
Eutectic mixture of austenite and Cementite.

5. Pearlite - It is a mechanical Mixture of ferrite and Cementite

6. Martensite :- It ~~is a~~ has a fine needle-like fibrous structure and is very hard and brittle.
It results due to the formation of an interstitial Solid Solution of Carbon in α- Iron.

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Classification of heat treatment processes :-

1) Annealing
2) Normalising
3) Hardening
4) Tempering
5) Case Hardening
6) Surface Hardening
7) Diffusion Coating

1) Annealing is indeed one of the most important heat-treatment processes.
The internal Structure of the metal gets Stabilized through this process.

i) To relieve internal Stresses Set up during earlier operations

ii) To effect changes in Some mechanical, electrical and magnetic properties.

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Different types of annealing processes can be classified as follows :-

i) Full annealing
ii) process ,,
iii) Spheroidise ,,
iv) Diffusion ,,
v) Isothermal ,,

i) Full annealing - The main objective of this type of annealing are to soften the metal, releive its stresses and refine its grain structure.

Heating of steel to a temperature about 30°c to 50°c above the higher critical point.

ii) Process Annealing →
It is also known as low temperature annealing or Sub-critical annealing or commercial annealing.

purpose of this process is to remove the ill effects of cold working and soften the metal so that it's ductility is restored.

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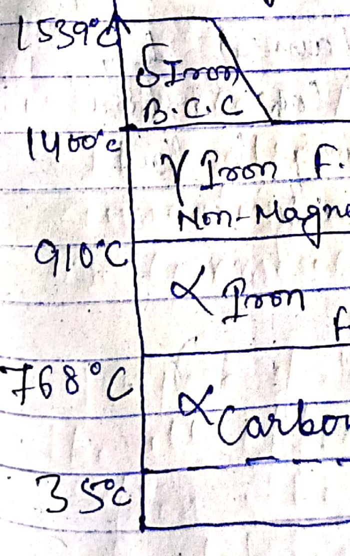
(iii) Spheroidise Annealing -
The main objectives in this process of annealing is to produce a Structure of Steel Consists of globules or well dispersed Spheroids of Cementite in ferrite.

(iv) Diffusion annealing →
This process is mainly used for Steel castings before applying full annealing. The purpose of this treatment is to remove the heterogeneity in the Chemical Composition of Steel ingot and heavy castings.
Heating temp upto 1100°C to 1200°C

Annealing → Re

Micro Structure
↓
Atomic arrang
Grain Structu
(>100x)
↓
Material prop
↓
Changes
↓
Atomic arra
↓
Heating an
process

* Cooling



(22)

Normalising →

The process is Similar to annealing in Sequence but differs a lot in the heating temperature range, holding time and the rate of cooling.

In this process, Steel is heated to a temp 40°C to 50°C above the higher Critical point.

Hardening :- In this ~~method~~ process Heating Steel to a temp within the hardening range which is 30°C to 50°C above the higher Critical point. holding temperature for sufficient time ~~to allow~~ and then Cooling rapidly by quenching in a Suitable medium like water, oil

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Nitriding → This process, which is basically a surface hardening process is based on the absorption of nitrogen by the metal and no quenching is required.

1) gas Nitriding
2) Salt bath Nitriding

Cyaniding → In this process the metal absorbs Carbon and Nitrogen to acquire a hardened surface layer.

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Introduction to Shaft.

A Shaft is a rotating machine element which is used to transmit power from one place to another. The power is delivered to the Shaft by Some tangential force and the resultant torque (or twisting moment) Set up within the Shaft permits the power to be transferred to various Machine linked up to the Shaft.

In order to transfer the power from one shaft to another, the various members such as pulleys, gear etc. are Mounted on it.

Materials used for Shafts.

The material used for shafts Should have the following properties:

1. It Should have high Strength.
2. It Should have good machinability.
3. It Should have low notch Sensitivity factor.
4. It Should have high wear resistant properties.

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Manufacturing of Shafts

Shafts are generally manufactured by hot rolling and finished to size by cold drawing or turning and grinding. The cold rolled shafts are stronger than hot rolled shafts but with higher residual stresses.

The residual stresses may cause distortion of the shaft when it is machined, especially when slots or keyways are cut. Shafts of larger diameter are usually forged and turned to size in a lathe.

Types of Shafts :-

The following two types of shafts are important from the subject point of view :

(i) Transmission Shafts :- These shafts transmit power between the sources and the machines absorbing power. The counter shafts, line shafts, over head shafts and all factory shafts are transmission shafts. Since these shafts carry machine parts such as pulleys, gears etc

(ii) Machine Shafts: These Shafts form an Integral part of the Machine itself. The Crank Shaft is an Example of Machine Shaft.

Standard Sizes of Transmission Shafts.

The Standard Size of transmission Shafts are:

25 mm to 60 mm with 5 mm. Steps;
60 mm to 110 mm with 10 mm Steps;
110 mm to 140 mm with 15 mm ,,
140 mm to 500 mm with 20 mm Steps

The Standard length of the Shafts are 6 m, 7 m.

Design of Shafts :-

The Shafts may be designed on the basis of

(i) Strength, and (ii) Rigidity and Stiffnes

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INTRODUCTION OF KEYS

A Key is a piece of Mild Steel inserted between the Shaft and hub or boss of the pulley to Connect these together in order to prevent relative motion between them.

It is always Inserted parallel to the axis of the Shaft.

Keys are used as temporary fastenings and are Subjected to Considerable Crushing and Shearing Stresses.

Types of Keys :-

The following types of Keys are important from the Subject point of view:

1) Sunk Keys
2) Saddle Keys
3) Tangent Keys
4) Round Keys
5) Splines.

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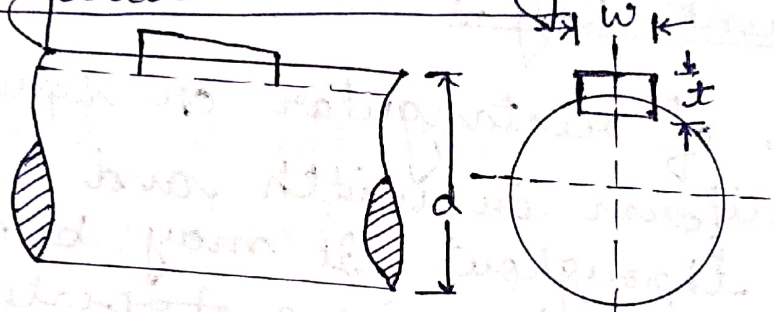
(1) Sunk Keys :-

The Sunk Keys are provided half in the Keyway of the Shaft and half in the Keyway of the hub or boss of the pulley.

Types of Sunk Key :-

(i) Rectangular Sunk Key :-



A Rectangular Sunk Key the usual proportions of this key are:

Width of Key, $w = \frac{d}{4}$

thickness of Key, $t = \frac{2w}{3} = \frac{d}{6}$

where d = diameter of the Shaft or diameter of the hole in the hub

The Key Has the Taper 1 in 100 on the top Side only.

(ii) Square Sunk Key :-

The only difference between a rectangular Sunk Key and a Square Key is that its width and thickness are equal i.e. $w = t = \frac{d}{4}$.

(iii) parallel Sunk Key :-

It may be of rectangular or square Section uniform in width and thickness throughout. It may be noted that a parallel key is a ~~taperless~~ and is used where the pulley, gear or other mating piece is required to Slide along the Shaft.

Gib-head Key -

It is a rectangular Sunk key with a head at one end Known as gib head. It is usually provided to facilitate the removal of key.

$w = \frac{d}{4}$, thickness at large end

$t = \frac{2w}{3} = \frac{d}{6}$

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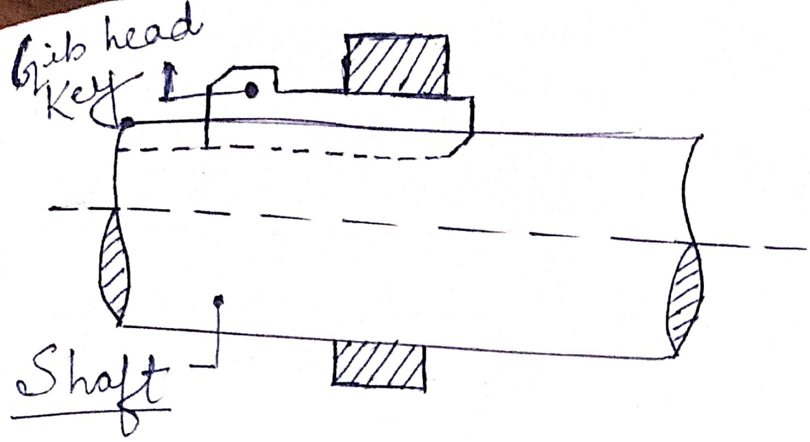

(2) Saddle Keys :-

The Saddle Keys are of the following two types :

(i) Flat Saddle Key.

(ii) Hollow Saddle Key.

(i) Flat Saddle Key - It is a taper Key which fits in a Keyway in the hub and is flat on the Shaft. It is likely to Slip around the Shaft under load.

Therefore it is used for Comparatively light loads.

(ii) A hollow Saddle Key is a taper key which fit in a Keyway in the hub and the bottom of the Key is Shaped to fit the Curved Surface of the Shaft.

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Shaft Coupling:

Unit - II.

Shafts are usually available upto 7m length due to inconvenience in transport. In order to have a greater length it becomes necessary to Join two or more pieces of the Shaft by means of a Coupling. A good Shaft Coupling Should have the following requirements:-

1) It Should be easy to connect or disconn
2) It Should transmit the full power from one shaft to the other Shaft without losses.
3) It Should hold the Shaft in perfect alignment.

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Two main types of shaft Couplings are as follows:-

1) Rigid Coupling.
2) Flexible Coupling.

*Rigid Coupling:- It is used to Connect two Shafts which are perfectly aligned

Types:-

1) Sleeve or Muff Coupling
2) Clamp or Split muff or Compression Couplings and
3) Flange Coupling.

2) Flexible Coupling:- It is used to Connect to Shafts having both Lateral and angular misalignment

Types:-

a) Bushed pin type Coupling
b) Universal Coupling and
c) Oldham Coupling.

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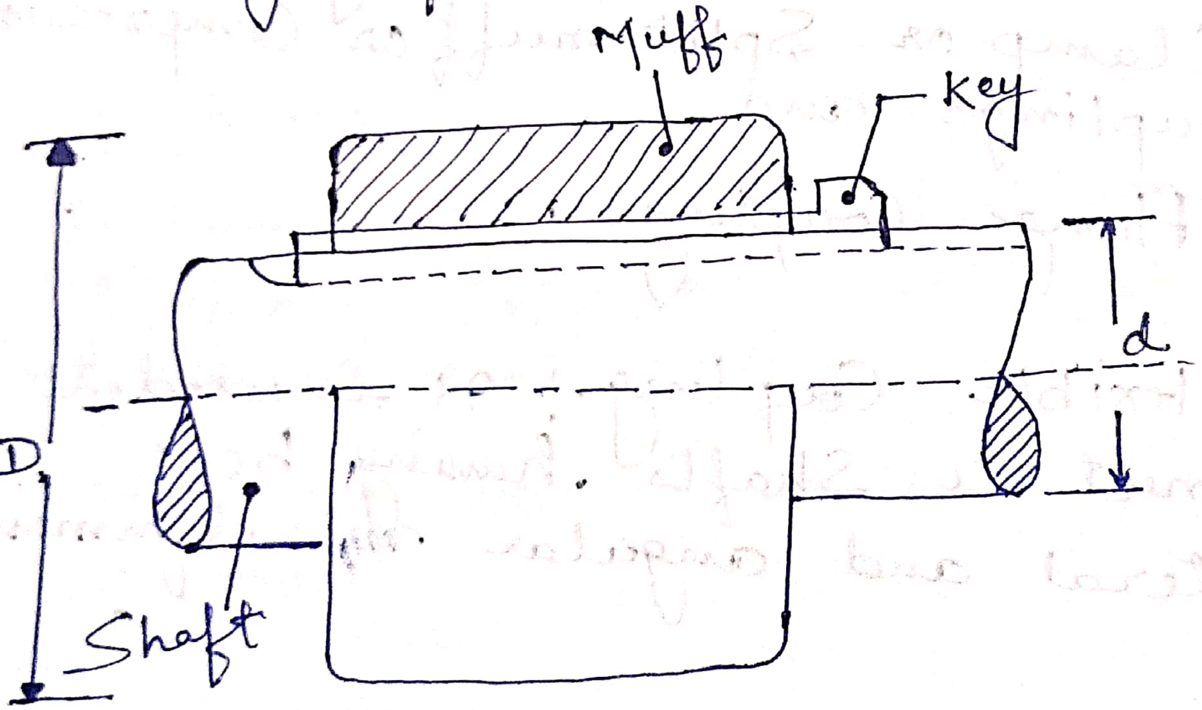
Sleeve or Muff Coupling :-

The Sleeve or muff Coupling is designed as a hollow Shaft.

The usual proportions of a Cast Iron Sleeve Coupling are as follow

outer diameter of the muff or Sleeve = 2d + 13 mm

and length of the muff or Sleeve = 3.5d



Flange Coupling

- A flange Coupling usually applies to a Coupling having two Separates Cast Iron flanges.
- Each flange is mounted on the Shaft end and Keyed to it.
- The faces are turned up at right angle to the axis of the Shaft.

(i) unprotected type flange Coupling
In an unprotected type flangecoupling, each Shaft is Keyed to the boss of a flange with a counter. Sunk Key and the flanges are Coupled together by means of bolts.
Generally three four Six bolts are use
The Keys are Staggered at right angle along the Circumference of the Shafts in order to divide the weaking effect Caused by Keyways.

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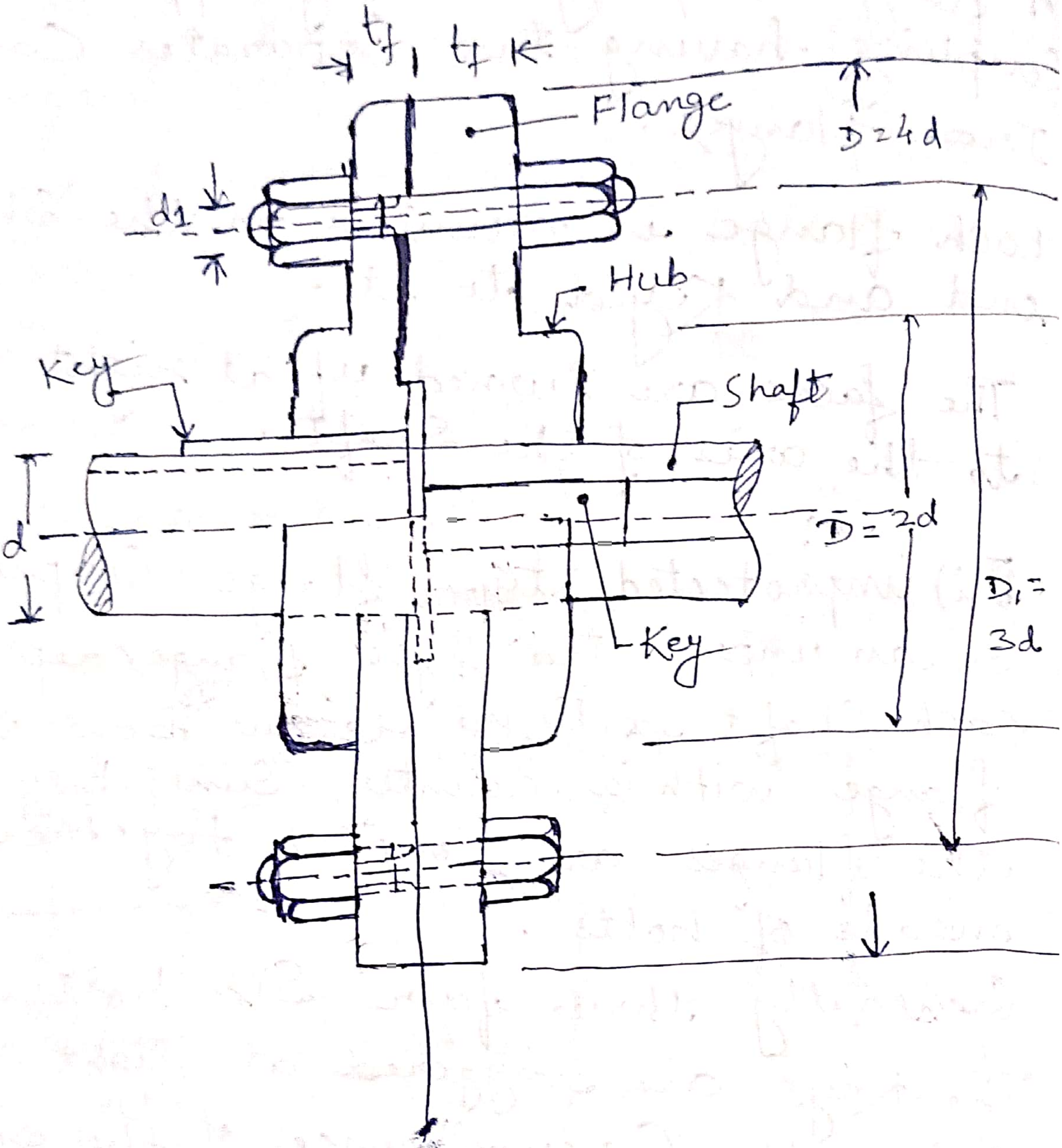

If d is the diameter of the shaft or inner diameter of the hub, then

$D = 2d$

Length of the hub

$L = 1.5d.$

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2) Protected type flange Coupling -:

In a this type of flange Coupling, the protruding bolts and Nuts are protected by flanges on the two halves of the Coupling, in order to avoid danger to the workman.

The thickness of the protective Circumferential flange (fp) is ~~taken~~ as 0.25d.

The other proportions of the coupling are same as for unprotected type flange Coupling.

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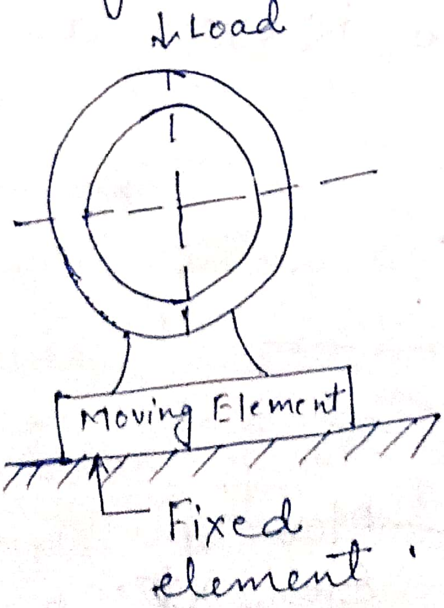
Bearing

A bearing is a Machine element which Support another moving Machine element (Known as Journal). It permits a Relative Motion between the contact surfaces of the members, while carrying the load.

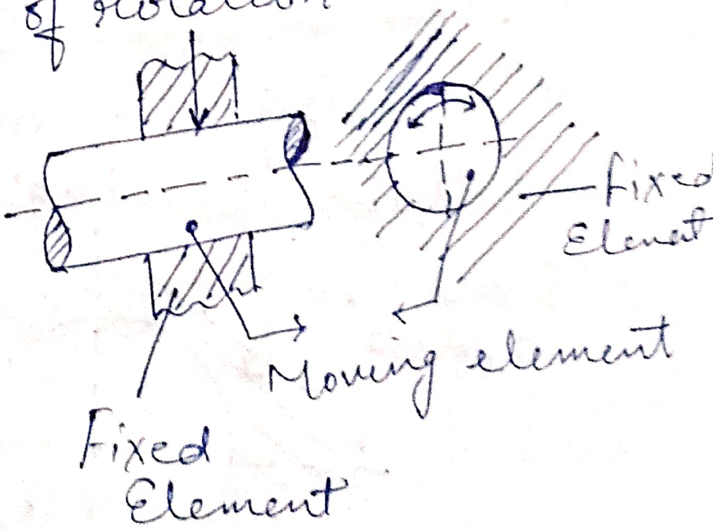
The bearing may be classified as follows :- (A) Depending upon the direction of load to be Supported:

1) Radial Bearings :- In radial bearings, the load acts perpendicular to the direction of Motion of the moving element.

2) Thrust Bearing :- The load acts along the axis of rotation



(a) Radial Bearing



Radial Bearing

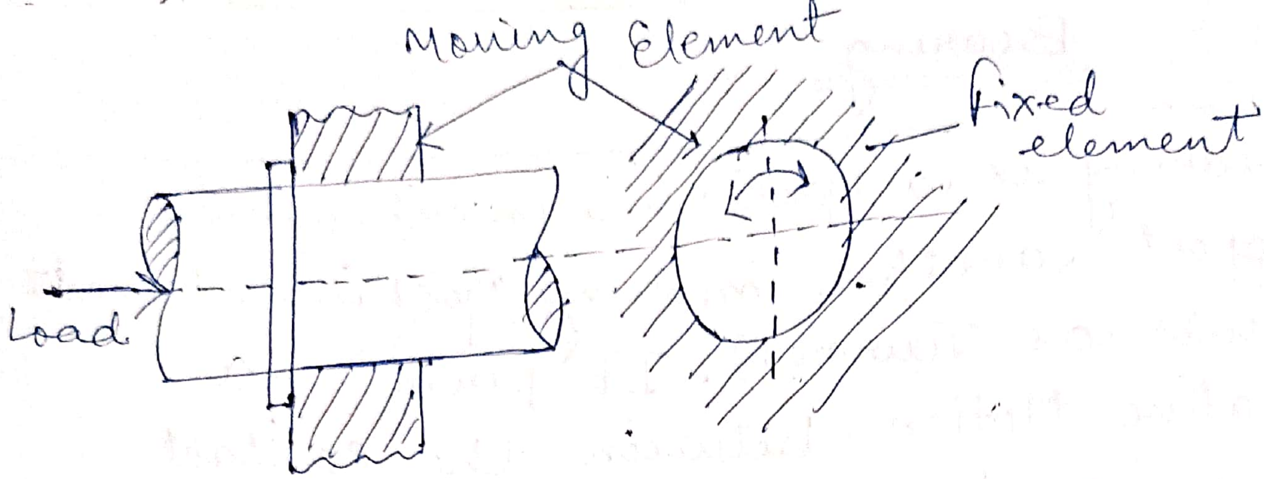


Fig :- Thrust Bearing

b) Depending upon the nature of Contact.

(I) Sliding Contact bearings,
The sliding takes place along the Surfaces of contact between the moving element and the fixed element. The Sliding Contact bearing are also known as Plain bearings.

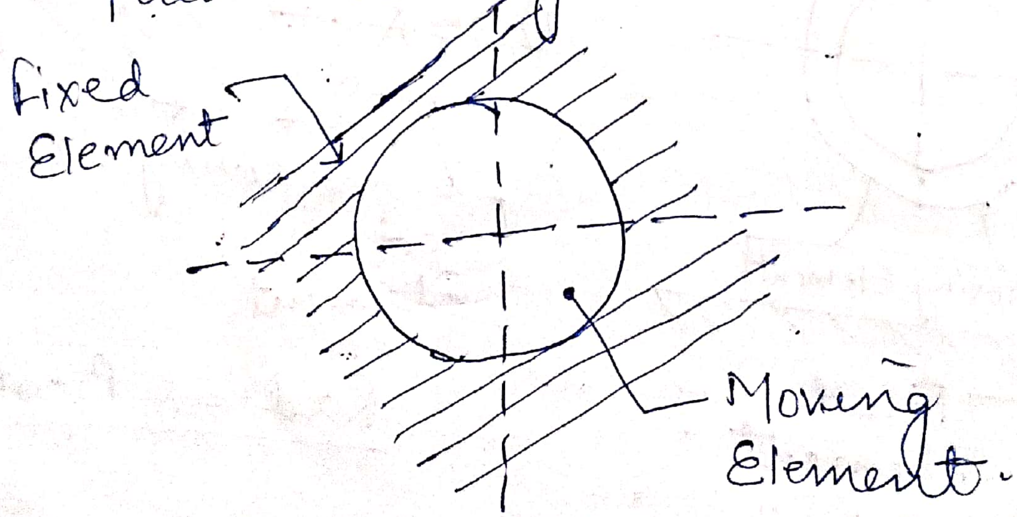


fig - Sliding Contact bearing.

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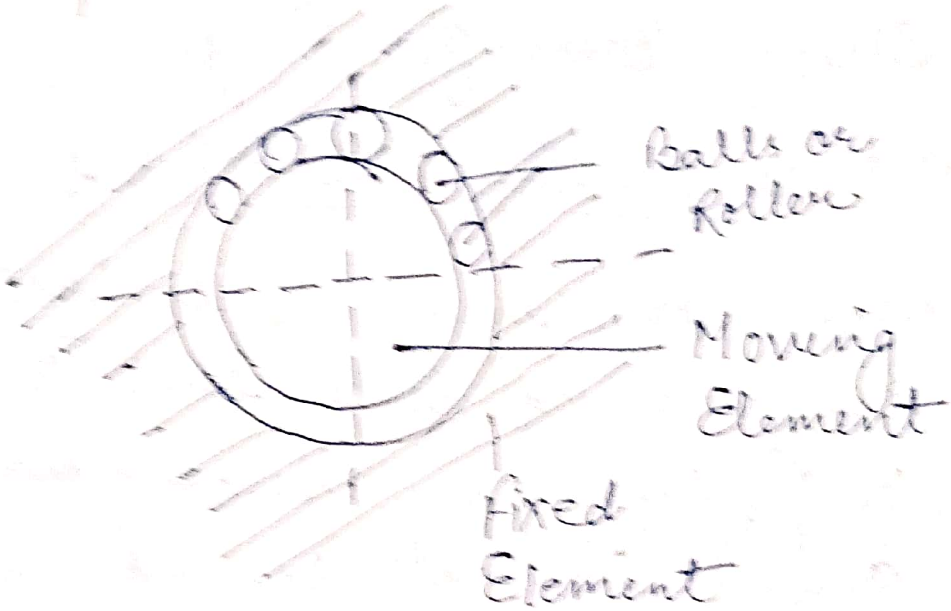
(b) Rolling contact Bearing :-

The Steel balls or roller, are interposed between the moving and fixed Elements. The ball offer rolling friction at two points for each ball or roller.



Types of Sliding contact Bearings-

The Sliding contact bearings in which the Sliding action is guided in a Straight line and carrying radial loads, may be called Slipper or guide bearings. Such type of bearing are usually found in Cross. ~~Sectional~~ head of Steam Engines.

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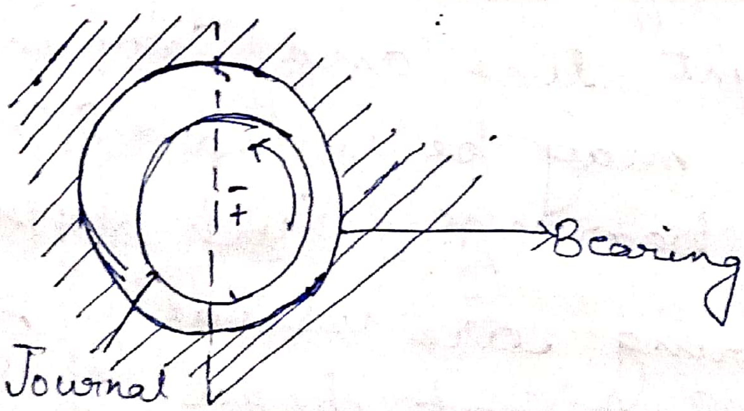
The Sliding contact bearing in which the Sliding action is along the Circumference of a Circle or an arc of a Circle and Carrying radial load are Known as Journal or Sleeve Bearings.

(a) <u>Full Journal Bearing</u> :-

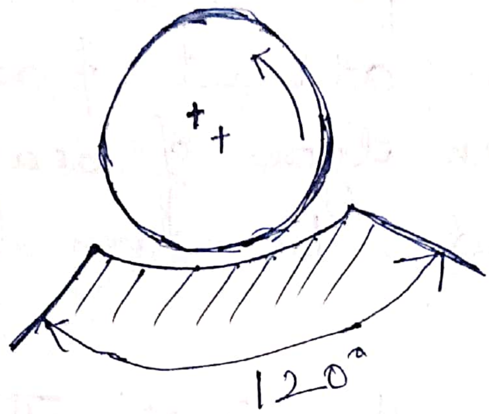
When the angle of contact ~~between~~ of the bearing with the Journal is 360°, then the bearing is Called a full Journal bearing.

<u>uses</u> :-

i) In Industrial Machinery to accomodate bearing loads in any radial direction.



b) Partial Journal Bearing →
when the angle of Contact of the bearing with the Journal is 120°, then the Bearing is Known as Partial Journal Bearing.



(ii) The Sliding contact bearings, according to the thickness of layer of the lubricant between the bearing and the Journal.

1) Thick film bearings - The thick film bearings are those in which the working Surfaces are Completely Separated from each other by the lubricant. Such type of bearing are also Called as hydrodynamic lubricated bearings.

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(2) Thin film lubricants – The ~~film~~ thin film bearings are those in which, although lubricant is present, the working surfaces partially contact each other atleast part of the time. Such type of bearings are also called boundary lubricated bearings.

(3) Zero film bearings – The zero film bearings are those which operates without any lubricant present.

Properties of Sliding Contact Bearing Materials :–

1) Compressibility Strength
2) Fatigue Strength
3) Thermal Conductivity
4) Thermal Expansion.
5) Corrosion Resistance.

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Materials used for Sliding contact Bearings :—

(1) Babbit Metal →

Tin base Babbits :- Tin 90%; Cu 4.5%; Antimony 5%, Lead 0.5%

Lead base Babbits –

Lead 84%, Tin 6%, Antimony 9.5%. Cu 0.5%.

It is used where Maximum bearing pressure is Not over 7 to 14 N/mm^2.

It is used as a thin layer 0.05 mm to 0.15 mm thick

(2) Bronze – (Alloys of Cu, Zinc and tin) are generally used in the form of Machined bushes pressed into the Shell. Bush may be in one or two pieces.

Bronze commonly used for bearing Materials are gun Metal and Phosphor Bronzes.

Gun Metal (Cu 88%, Tin 10%, Zinc 2%).

uses -!

for high grade bearings Subjected to high Pressures and high Speeds. above 10 N/mm^2.

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Phosphor bronzes →
Cu 80%, Tin 10%, Lead 9%, Phosphorus 1%
Uses →
Bearing subjected to very high pressure and speeds above 14 N/mm².

(2) Cast Iron → The cast iron journal are usually used with steel journals.
It is used where pressure is limited to 3.5 N/mm², and speed to 40m/minute.

(3) Silver → It is usually used in Air craft engines.

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Thrust Bearings.

A thrust Bearing is used to guide or Support the Shaft which is Subjected to a load along the axis of the Shaft.

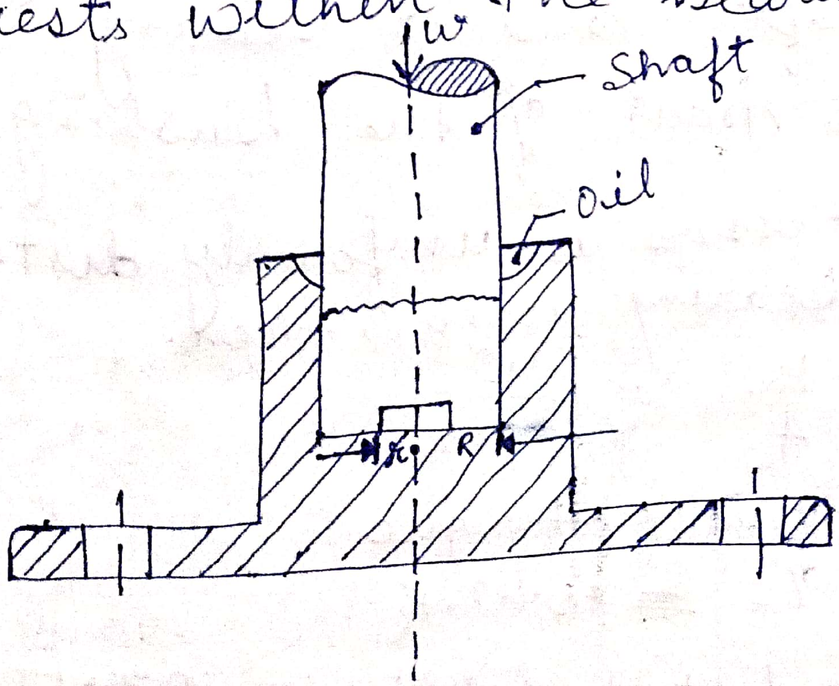
Such types of Bearings are mainly used in turbines and propeller Shafts.

It is of two types :-

i) Foot Step or pivot bearings and

ii) Collar bearings.

In a foot Step or pivot bearing, the loaded Shaft is vertical and the ~~at~~ end of the Shaft rests within the bearings.



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Working :- The shaft rests on a pad inside the bearing, and a pin prevents the pad from rotating. The pin is inserted halfway into the block and halfway into the pad. The collar of the bushing is hollow and acts as an oil cup to lubricate the bearing.

Construction :- A foot step bearing is a cylindrical block with a cavity that holds the shafts. It is made up of two parts: a tubular bushing that guides the shaft, and a bearing step at the front of the bushing.

When the pressure is uniformly distribute over the bearing area, then.

$$P = \frac{W}{A} = \frac{W}{\pi R^2}$$

Total frictional torque

$$T = \frac{2}{3} \mu \cdot W \cdot R$$

$\therefore$ power lost in friction $= \frac{2\pi N T}{60}$ wā

Collar bearings:—

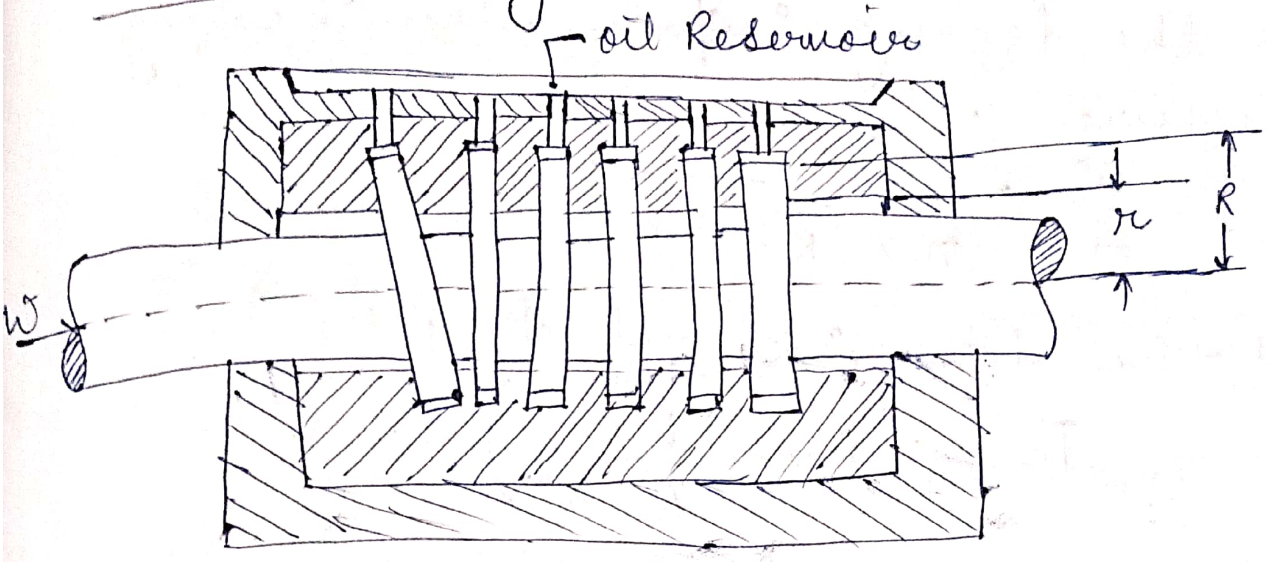

fig:- Collar Bearing

In a collar bearing, the Shaft Continues through the bearing. The Shaft may be Vertical Or Horizontal, with Single Collar or many Collar

A Simple multi Collar bearing for horizontal Shaft is Shown in fig

The collar are either Rigidly fastened to it or either integral parts of the Shaft.

The outer diameter of the ~~Shaft~~ Collar is usually taken as 1.4 to 1.8 times the inner diameter of the Collar

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when the pressure is uniformly distributed over the bearing Surface, then bearing pressure

$$p = \frac{W}{A} = \frac{W}{n.\pi(R^2 - r^2)}$$

and the total frictional torque,

$$T = \frac{2}{3}\mu.W\left(\frac{R^3 - r^3}{R^2 - r^2}\right)$$

∴ Power lost in friction

$$P = \frac{2\pi NT}{60} \text{ watts.}$$

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Roller Contact bearing

Advantages :-

1) Low Starting and running friction Except at very high speeds.
2) Ability to withstand momentary Shock loads.
3) Accuracy of shaft alignment.
4) Cleanliness.
5) Reliability of service.
6) Small over all dimensions

Disadvantages :-

1) More Noisy at very high speed.
2) Low Resistance to Shock loading
3) More initial Cost
4) Design of bearing housing Complicated.

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Unit – II

Shaft Coupling:

Shafts are usually available upto 7m length due to inconvenience in transport. In order to have a greater length it becomes necessary to join two or more pieces of the shaft by means of a coupling. A good shaft coupling should have the following requirements:–

1) It should be easy to connect or disconnect
2) It should transmit the full power from one shaft to the other shaft without losses.
3) It should hold the shaft in perfect alignment.

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Two main types of shaft couplings are as follows:-

1) Rigid Coupling.
2) Flexible Coupling.

*Rigid Coupling :- It is used to Connect two Shafts which are perfectly aligned

Types :-

1) Sleeve or Muff Coupling
2) Clamp or Split muff or Compression Couplings and
3) Flange Coupling.

2) Flexible Coupling :- It is used to Connect to Shafts having both Lateral and angular misalignment

Types :-

a) Bushed pin type coupling
b) Universal Coupling and
c) oldham Coupling.

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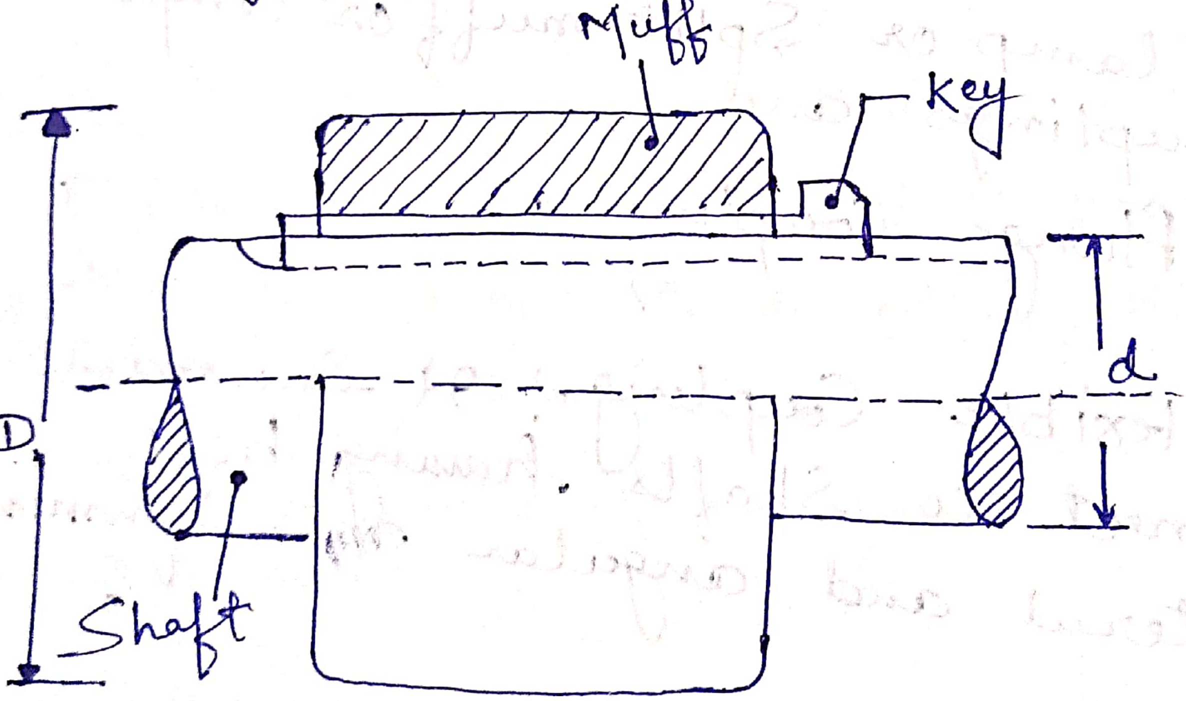
Sleeve or Muff Coupling :-

The Sleeve or muff Coupling is designed as a hollow Shaft.

The usual proportions of a cast Iron Sleeve Coupling are as follow

Outer diameter of the muff or Sleeve = 2d + 13 mm

and length of the muff or Sleeve = 3.5d

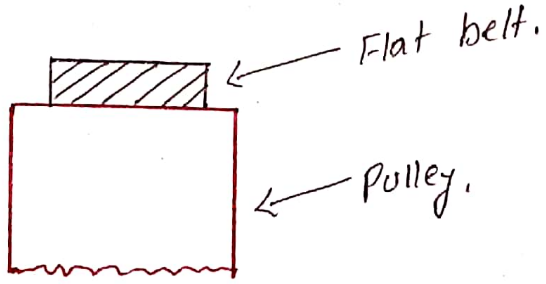


Belt drive :-

A belt drive is a frictional drive that transmit power between two or more shaft using pulleys and an elastic belt.

Types of Belt :

1) Flat belt :- The flat belt are mostly used in factories and workshop, where a moderate amount of power is to be transmitted, from one pulley to another, when the two pulleys are not more than 8 meter's apart.



2) V belt :-

The v-belt are mostly used in factories and workshop, where a moderate amount of power is to be transmitted from one shaft to another, when the two pulleys are very near to each other.

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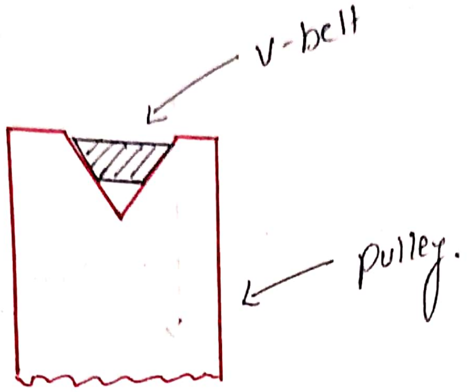

3) Circular Belt :-

The circular belt or rope is mostly used in factories or workshop where a great amount power is to be transmitted from one pulley to another when two pulley are more than 8m apart.

Material used for belts :-

The material used for belt and ropes must be strong, flexible and durable. It must have a high co-efficient of friction. The belts, according to material used,

1) Leather belts.
2) cotton or fabric belt.
3) Rubber belt.
4) Balata belt.

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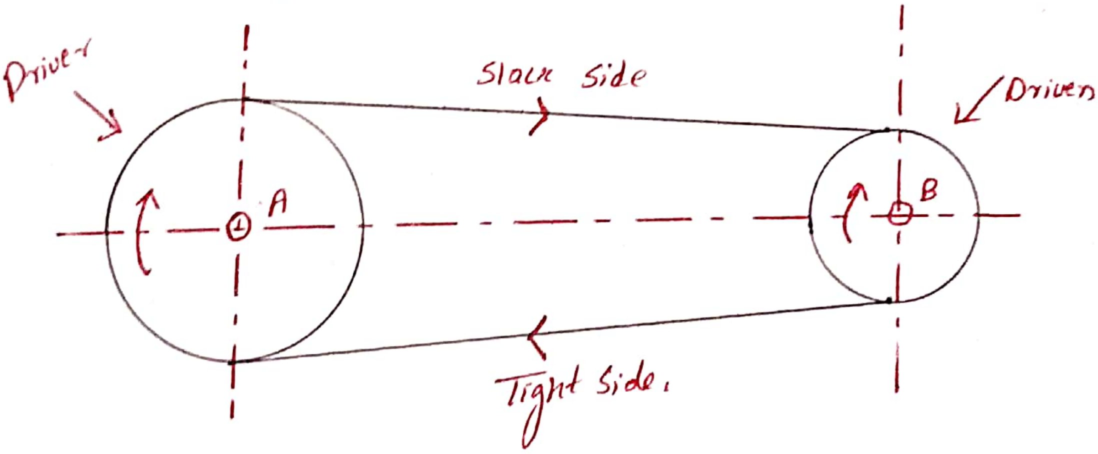
Types of Flat belt drive :-

1) Open belt drive :-

The open belt drive is used with shaft arranged parallel and rotating in same direction. In this case driver 'A' pulls the belt from one side and deliver the belt to the another side. Thus the tension is more in lower side called tight side, and the tension will be less in the upper side called slack side.



Velocity ratio of belt drive.

$$V.R = \frac{N_2}{N_1} = \frac{d_1}{d_2}$$

N_1 = Speed of driver

N_2 = Speed of driven

T_1 = No. of teeth in driver

T_2 = No. of teeth in driven.

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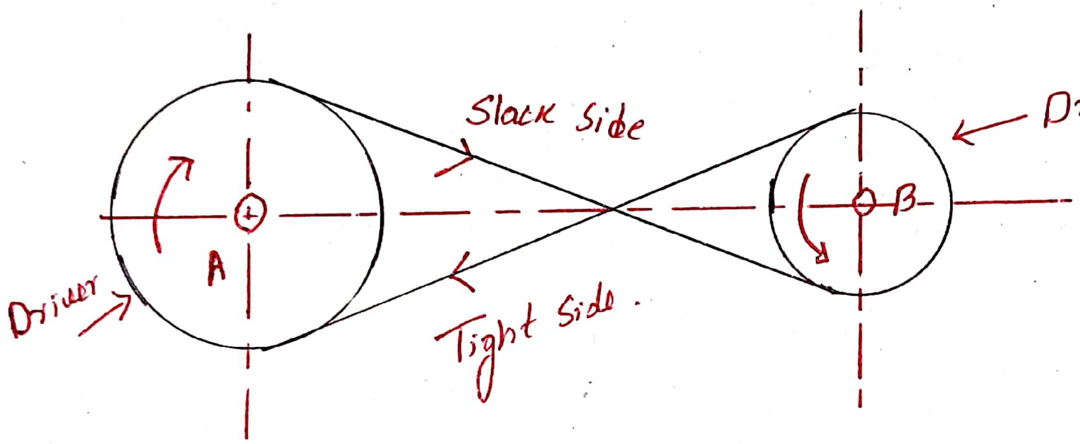
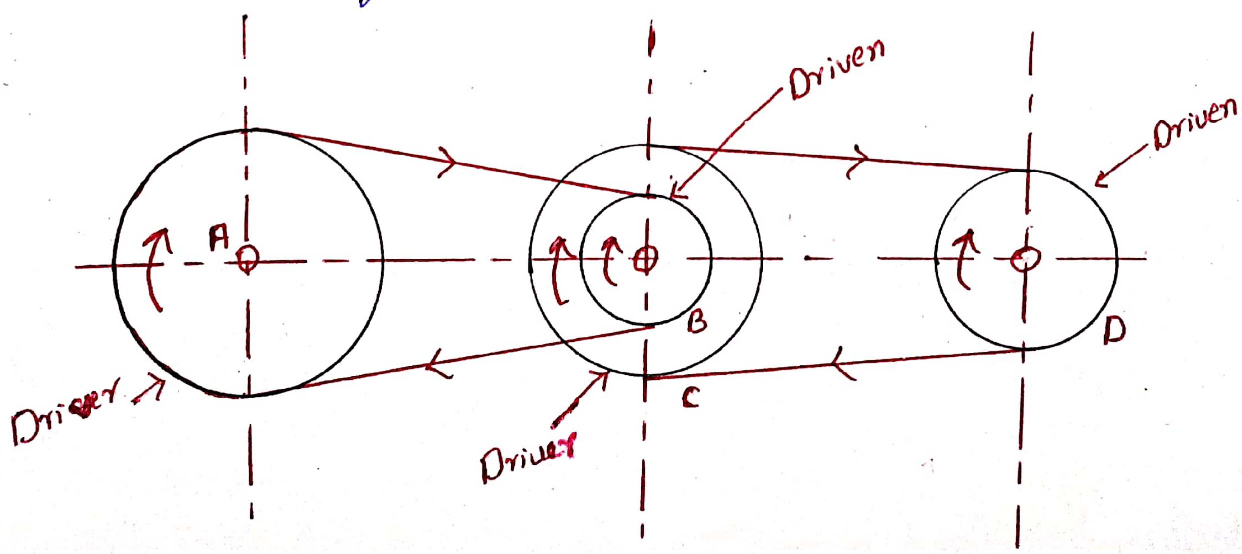
2) Cross belt drive :-

The cross belt drive is used with shaft arranged parallel and rotating in opposite direction.



3) Compound belt drive :-

A compound belt drive is used when power is transmitted from one shaft to another through a number of pulleys.



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A shaft rotating at 200 rpm drives another shaft at 300 rpm and transmits 6 KW through a belt. The belt 100 mm wide and 10mm thick. The distance between the shaft is 4m. The smaller pulley is 0.5m in diameter. Calculate the stress in the belt, if it is 1) an open belt drive. 2) A cross belt drive.

Take $\mu = 0.3$.

Soln:- Given

$N_1 = 200$ rpm, $N_2 = 300$ rpm, $P = 6000$ N, $b = 100$mm, 0.1m.

$t = 10$mm, 0.01 mm, $x = 4$m, $d_2 = 0.5$m, $\mu = 0.3$.

1) Stress in the belt for an open belt drive:-

$$\frac{N_2}{N_1} = \frac{d_1}{d_2} \Rightarrow \frac{300}{200} = \frac{d_1}{0.5} \Rightarrow d_1 = \frac{300 \times 0.5}{200}$$

$\therefore d_1 = 0.75$m.

$$\therefore V = \frac{\pi d_2 N_2}{60} = \frac{\pi \times 0.5 \times 300}{60} = 7.855 \text{ m/s}.$$

Now let us find the angle contact.

$$\sin\alpha = \frac{r_1 - r_2}{x} = \frac{0.375 - 0.25}{4} = 0.03125.$$

$\therefore \alpha = 1.8°$.

Angle of contact $\theta = 180° - 2\alpha = 176.4°$.

$\theta = 3.08$ rad.

wrapts.

we know that.

$$2.3 \log \frac{T_1}{T_2} = \mu\theta. \Rightarrow \frac{T_1}{T_2} = 2.52. \text{ —(I).}$$

Power transmitted. (P).

$$6000 = (T_1 - T_2)v$$

$$(T_1 - T_2) = 764 \text{ N}$$

from (I) & (II)

$$T_1 = 1266.$$

$$T_2 = 502 \text{ N}.$$

$\therefore$ max tens. = $T_1 = \sigma \cdot b \cdot t.$

$$\therefore \sigma = \frac{T_1}{b \times t} = 1.266 \text{ N/mm}^2$$

Q4) An open belt drive connects two pulleys 1.2m and 0.5m diameter, on a parallel shaft 4m apart. The mass of the belt is 0.9kg/m length and maximum tension is not to exceed 2000N. The co-efficient of friction is 0.3. The driver pulley runs at 200 rpm. Due to belt slip on one of the pulleys, the velocity of driven shaft is 450 rpm. Calculate the torque on each of the two shafts, Power transmitted and power loss due to slip. and efficiency of the driven.

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Similarly, a belt marked $A - 914 - 48$ denotes an undersize belt, whose pitch length will be $950 - 2 \times 2.5 = 945$ mm.

20.4 Advantages and Disadvantages of V-belt Drive over Flat Belt Drive

Following are the advantages and disadvantages of the *V*-belt drive over flat belt drive :

Advantages

1. The *V*-belt drive gives compactness due to the small distance between centres of pulleys.
2. The drive is positive, because the slip between the belt and the pulley groove is negligible.
3. Since the *V*-belts are made endless and there is no joint trouble, therefore the drive is smooth.
4. It provides longer life, 3 to 5 years.
5. It can be easily installed and removed.
6. The operation of the belt and pulley is quiet.
7. The belts have the ability to cushion the shock when machines are started.
8. The high velocity ratio (maximum 10) may be obtained.
9. The wedging action of the belt in the groove gives high value of limiting *ratio of tensions. Therefore the power transmitted by *V*-belts is more than flat belts for the same coefficient of friction, arc of contact and allowable tension in the belts.
10. The *V*-belt may be operated in either direction, with tight side of the belt at the top or bottom. The centre line may be horizontal, vertical or inclined.

Disadvantages

1. The *V*-belt drive can not be used with large centre distances, because of larger weight per unit length.
2. The *V*-belts are not so durable as flat belts.
3. The construction of pulleys for V-belts is more complicated than pulleys of flat belts.
4. Since the *V*-belts are subjected to certain amount of creep, therefore these are not suitable for constant speed applications such as synchronous machines and timing devices.
5. The belt life is greatly influenced with temperature changes, improper belt tension and mismatching of belt lengths.
6. The centrifugal tension prevents the use of *V*-belts at speeds below 5 m / s and above 50 m / s.

... Driving Tensions for V-belt

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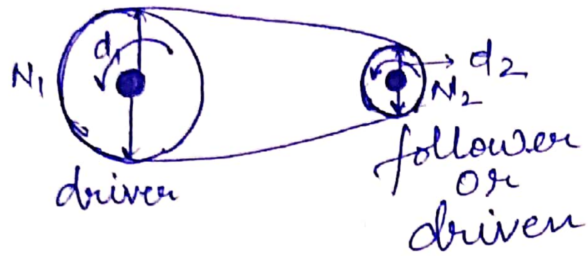
Velocity Ratio of a Belt Drive.



It is the Ratio between the velocities of the driver and the follower or driven.

It may be Expressed, Mathematically, as discussed below,

Let d_1 = Diameter of the driver,
d_2 = Diameter of the driven
N_1 = Speed of the driver (r.p.m,)
N_2 = " " " driven (r.p.m),

∴ Length of the belt that passes over the driver, in one minute.

$= \pi d_1 N_1$.

Similarly, Length of the belt that passes over the driven, in one minute

$= \pi d_2 N_2$.

Since the length of belt that passes over the driver, in one minute is equal to the length of belt that passes over the driven, in one minute

$$\therefore \pi d_1 N_1 = \pi d_2 N_2$$

& V.R, $$\frac{N_2}{N_1} = \frac{d_1}{d_2}$$

{ when thickness of belt considered then V.R, $$\frac{N_2}{N_1} = \frac{d_1 + t}{d_2 + t}$$

Slip of the Belt :-

But Sometimes, the frictional grips become insufficient This may cause Some forward motion of the driver without carrying the ~~load~~ belt with it. This is called Slip of the Belt.

The result of the belt Slipping is to reduce the Velocity Ratio of the System.

Let $S_1\%$ = Slip between the driver and the belt, and

$S_2\%$ = Slip between the belt and follower,

∴ Velocity of the belt passing over the driver per Second,

$$V = \frac{\pi d_1 N_1}{60} - \frac{\pi d_1 N_1}{60} \times \frac{S_1}{100}.$$

$$= \frac{\pi d_1 N_1}{60}\left[1 - \frac{S_1}{100}\right] \quad \text{—(i)}$$

and velocity of the felt passing over the follower per Second.

$$\frac{\pi d_2 N_2}{60} = V - V\left[\frac{S_2}{100}\right] = V\left[1 - \frac{S_2}{100}\right]$$

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Substituting the value of v from equation (i), we have.

$$\frac{\pi d_2 N_2}{60} = \frac{\pi d_1 N_1}{60}\left[1-\frac{S_1}{100}\right]\left[1-\frac{S_2}{100}\right]$$

$$\therefore \quad \frac{N_2}{N_1} = \frac{d_1}{d_2}\left[1-\frac{S_1}{100}\right]\left[1-\frac{S_2}{100}\right]$$

$$\frac{N_2}{N_1} = \frac{d_1}{d_2}\left[1-\frac{S_1}{100}-\frac{S_2}{100}\right]$$

$$= \frac{d_1}{d_2}\left[1-\left(\frac{S_1+S_2}{100}\right)\right]$$

$$= \frac{d_1}{d_2}\left[1-\frac{S}{100}\right]$$

$$= \frac{d_1+t}{d_2+t}\left[1-\frac{S}{100}\right]$$

Creep of the Belt :-

When the belt passes from the slack side to the tight side, a certain portion of the belt extends and it contracts again when the belt passes from the tight side to the slack side. Due to these changes of length, there is a relative motion between the belt and the pulley surfaces. This relative motion is creep

Creep of Belt :-

when the belt passes from the slack side to tight side, a certain portion of the belt extends and it contracts again when the belt passes from the tight side to slack side. Due to these change of length, there is a relative motion between the belt and the pulley surface. This relative motion is termed as creep.

$$\frac{N_2}{N_1} = \frac{d_1}{d_2} \times \frac{E + \sqrt{\sigma_2}}{E + \sqrt{\sigma_1}}$$

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CHAIN DRIVES :-

We have seen in belt and rope drives that slipping may occur. In order to avoid slipping, steel chain are used. The chains are made up of rigid links which are hinged together in order to provide the necessary flexibility for wraping around the driving and driven wheels. The wheels have projecting teeth and fit into the corresponding constrained to move together without sliping and ensure perfect velocity ratio. The toothed wheels are known as sprockets.

Ex :- Bicycle, motor cycles, agricultural machinery etc.

* Advantages of chain drives :-

1) As no slip takes place during chain drive, hence perfect velocity ratio is obtained.

2) Since the chains are made of metals, therefore they occupy less space in width than belt or rope.

3) The chain drives may be used when the distance between the shaft is less.

4) The chain drive gives a high transmission efficiency (98%).

5) The chain drive can transfer motion to several shafts.

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* Disadvantages of chain drive :-

1) The Production cost of chains is relatively high.

2) The chain drive needs accurate mounting and care maintenance.

3) The chain drive has velocity fluctuations especially unduly streched.

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GEAR DRIVES

Advantages and Disadvantages of Gear drives

The following advantages and disadvantages of the gears drive as compared to other drives, i.e, belt, rope, and chain drives.

Advantages :-

1) It transmits exact velocity ratio.
2) It may be used to transmit large power
3) It has high efficiency.
4) It has reliable Service
5) It has Compact layout.

Disadvantages :-

1) Since the manufacturing of gears require Special tools and equipment, therefore. it is costlier than other devices
2) The error in cutting teeth may Cause vibrations and Noise during operation.

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Types of Gears.

Gears are Classified as follows :-

According to the position of axes of the Shafts.

Gears

- Parallel
  - Spur Gear
  - Rack Pinion
  - Helical Gear
- Intersecting
  - Bevel Gear.
- Non-Intersecting and Non-Parallel
  - Worm and worm wheel gear.

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GEARS

Gear are machine elements that transmit motion by means of successively engaging teeth. The gear teeth acts like small lever.

* Classification of Gear :-

Gears may be classified according to the relative position of the axes of revolution

The axes may be :-

① Parallel axes ② Intersecting axes ③ neither parallel nor intersecting axes.

① Parallel axes :- Spur gear, Helical gear, Spur rack and pinion, Internal gear.

* SPUR GEAR :- Teeth is parallel to axis of the rotation. The most common and easy to produce parallel shaft cylindrical gears. The gear teeth are straight along the length and parallel

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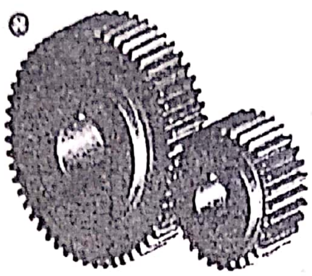
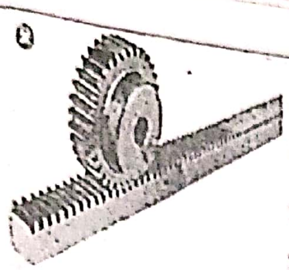
to the axis.



* HELICAL GEAR :- Quiet and able to transmit larger torque than Spur gears. Cylindrical gears with Spiral Shaped teeth trace.

* RACK & PINION :- A Spur rack is a Straight - Sided gear and can be considered as a Special case of Spur gear having infinite diameter. The most common application of this arrangement is in rotary to linear motion conversion vice-versa.



* Internal gear :- Gear teeth are cut on the inside surface of hollow cylindrical forms and used in planetary gear systems. The gear teeth are cut using shaper machines.

2) Intersecting Axes :- Bevel gear, Spiral bevel gears.

* Bevel gears :- In this type of gearing, the teeth are angled with respect to the axis i.e

* Bevel Gear's :- In this type of gearing, the axes are intersecting. The angle between the two axes know as shaft angle. It is usually 90°, but it can be of any other value also. Bevel gears are based on the rolling cones.

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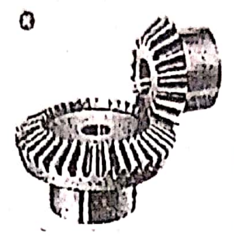
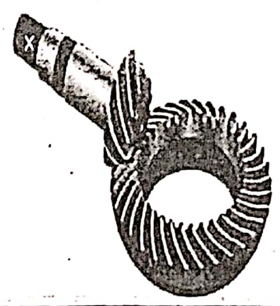
①



* **Spiral Bevel Gears:** In this type of gearing the teeth are angled with respect to the axis i.e. the teeth are curved in the shape of a spiral so that the contact between the inter-meshing teeth begins gradually and continues smoothly from one end to the other.



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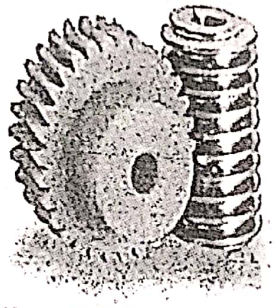
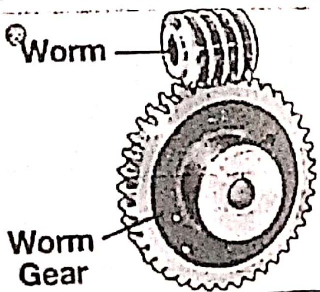
(3) Non-parallel axes :- Screw Gear, worm gear.

* Screw Gear :- used in offset shaft application. Shape wise, they are same as helical gear.



* Worm Gear :- used when a large speed reduction is needed. worm and worm gear set. In worm gears, the axes are non-intersecting and the planes containing the axes are normally at right angle to each other.



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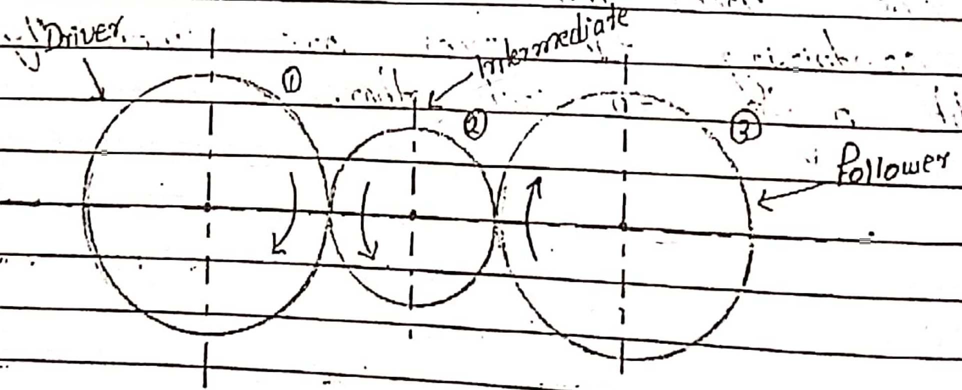
★ Types of Gear TRAINS :-

1) **Simple gear trains:-** If the axes of all gear remain fixed relative to each other, the gear train is known as simple gear train.

In case of a simple gear trains, each gear is on a separate shaft. Each gear is mounted on the separate shaft. The combination of these two gears is known as simple gear train.

In the figure given below. The shaft 1 is called the driver, where as shaft 3 is called the driven shaft and shaft 2 is called the intermediate shaft.



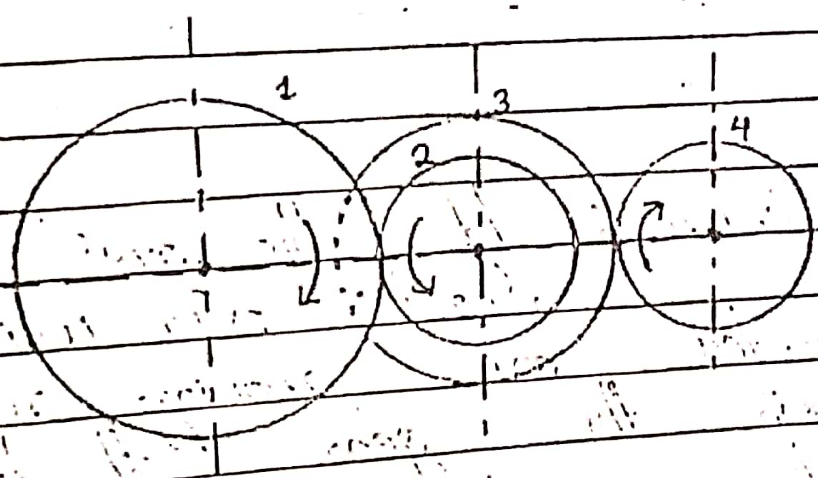
2) **Compound Gear Trains:-** In compound gear trains there are more than one gear on a shaft, generally intermediate shaft have two gears rigidly fixed to the shaft so that these two gears have the same speed

as they are mounted on same Shaft.

In the given figure

Gear 1 is the driver, which drives the gear 2 mounted on the intermediate Shaft. Gear 3 is also mounted on the intermediate Shaft which rotates the gear 4.

Here gear 2 & 3 rotates in same speed.



Velocity ratio of gear drive:

The velocity ratio of gear drive is defined as the ratio of the speed of the driven gear to the speed of the driving gears.

Let, d_1 = pitch circle diameter of driving gear

d_2 = pitch circle diameter of driven gear

T_1 = No of teeth on the driving gear

T_2 = " " " " " driven "

N_1 = Speed of driving gear in r.p.m

N_2 = " " driven " " r.p.m

If there is No Slip between the pitch circle of the two gear wheels, the linear speed of the two pitch cyl is equal,

Linear speed of the pitch cyl of driving gear = Linear speed of the pitch cyl of driven gear

$$\pi d_1 N_1 = \pi d_2 N_2$$

$$d_1 N_1 = d_2 N_2$$

$$\frac{N_2}{N_1} = \frac{d_1}{d_2} \quad \text{--- (1)}$$

The circular pitch of both matching gears remains same.

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$$\therefore P_c = \frac{\pi d_1}{T_1} = \frac{\pi d_2}{T_2}$$

$$\therefore \frac{d_1}{T_1} = \frac{d_2}{T_2}$$

$$\frac{d_1}{d_2} = \frac{T_1}{T_2} \quad \text{--- (2)}$$

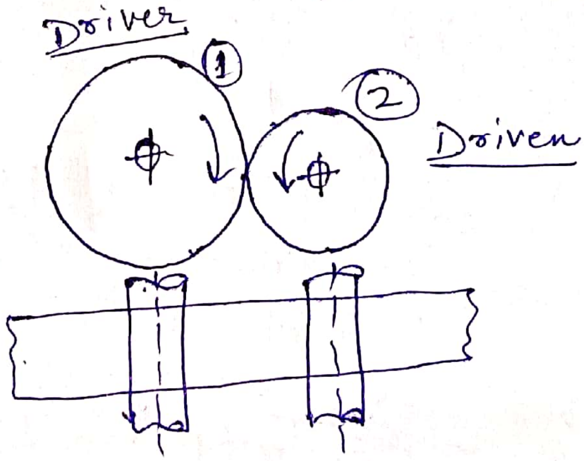
from Eqn (1) & (2) we get

V.R of gear drive

$$= \frac{N_2}{N_1} = \frac{d_1}{d_2} = \frac{T_1}{T_2}$$

Velocity Ratio of Simple gear drive

If two gears are Meshing so circular pitch should be equal.



$$P_c = \frac{\pi d_1}{T_1} = \frac{\pi d_2}{T_2}$$

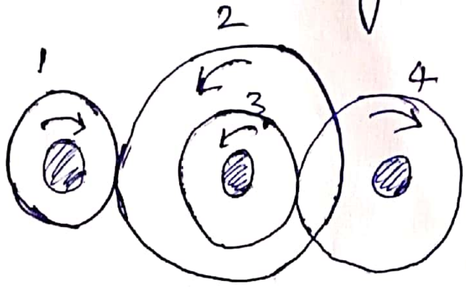
$$\frac{d_1}{T_1} = \frac{d_2}{T_2}$$

$$\frac{d_1}{d_2} = \frac{T_1}{T_2} \quad \text{--- (1)}$$

$$\pi d_1 N_1 = \pi d_2 N_2$$

$$\frac{N_1}{N_2} = \frac{d_2}{d_1} \quad \text{--- (2)}$$

Compound gear drive Velocity Ratio



$$\frac{N_2}{N_1} = \frac{d_1}{d_2} \quad \text{—(i)}$$

$$\boxed{N_2 = N_3}$$

$$\frac{N_4}{N_3} = \frac{d_3}{d_4} \quad \text{—(2)}$$

$$\frac{N_2}{N_1} \times \frac{N_4}{N_3} = \frac{d_1}{d_2} \times \frac{d_3}{d_4}$$

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Fasteners

Fasteners are devices used to Join, hold or fasten two or more parts together. Theses are essential components in various industries, manufacturing etc.

Types of fastenings (i.e Joints).

1) permanent fastenings and
2) Temparary or detachable fastenings.

1) Permanent fastenings are those fastenings which Can not be dissambled without destroying the connection components.
Eg:- Soldered, brazed, welded and riveted Joint.

2) Tempory Fastenings are those fastening which Can be dissambled without destroying the Connecting Components.
Eg:- Screwed, Keys, Cotters, pins and Splined Joint.

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SCREW THREADS

→ A screw thread is formed by cutting a helical groove on a cylindrical surface. The threaded rod is called a screw.

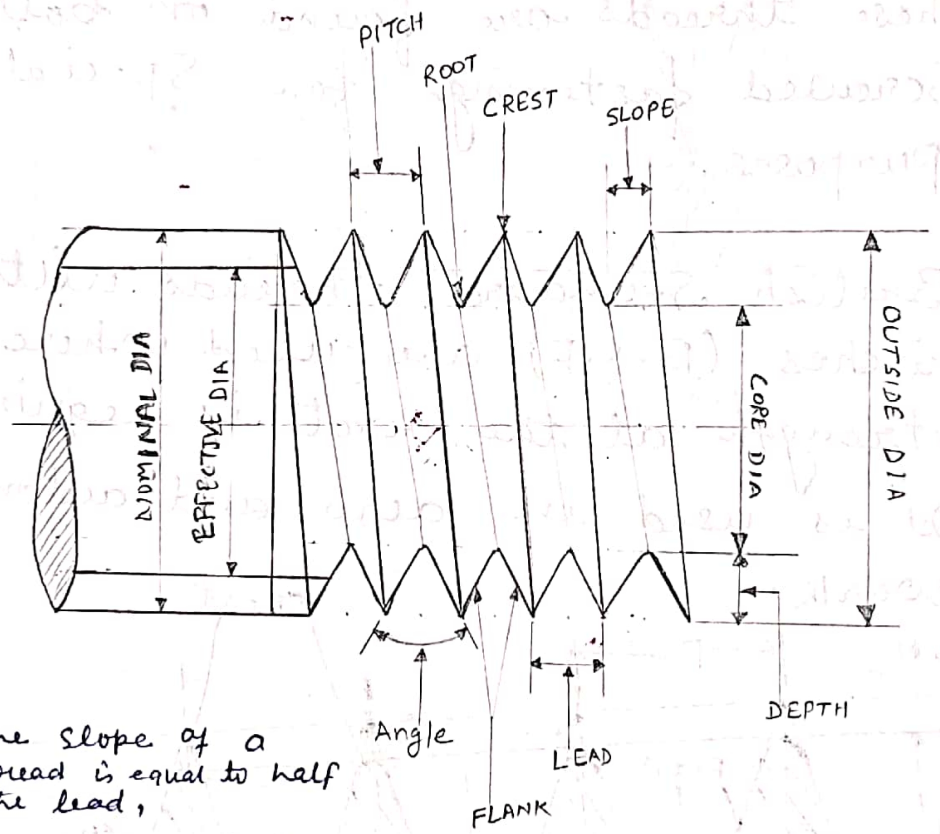
→ It engages in a corresponding threaded hole inside a nut or machine part.

→ The screws are used for joining two parts temporary. Therefore such a joint is called as temporary joints.

→ Threads are generally cut on a machine called lathe.

→ On a small-size screw, thread is often cut by means of tool called die.

→ ~~ab~~ a A small-size hole is threaded by means of tool called tap. such a hole is called a tapped hole.



Slope:- The slope of a thread is equal to half the lead,

Crest:- ~~Creast~~ crest is the outer-most part of a thread.

Root:- The root is the inner-most portion of a thread.

Flank:- The surface b/w the crest and the root is called flank.

Depth:- The depth is the distance b/w the crest and the root, measured at right angles to the axis.

Pitch:- It is the distance measured parallel to the axis, b/w a point on one thread ~~From~~ form and a corresponding point on the adjacent thread form. i.e. ~~one~~ from crest to crest or root to root

Lead:- It is the distance measured parallel to axis from a point on a thread to corresponding point on the same thread after one complete revolution.

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Forms of Screw Threads :-

(a) [illegible]

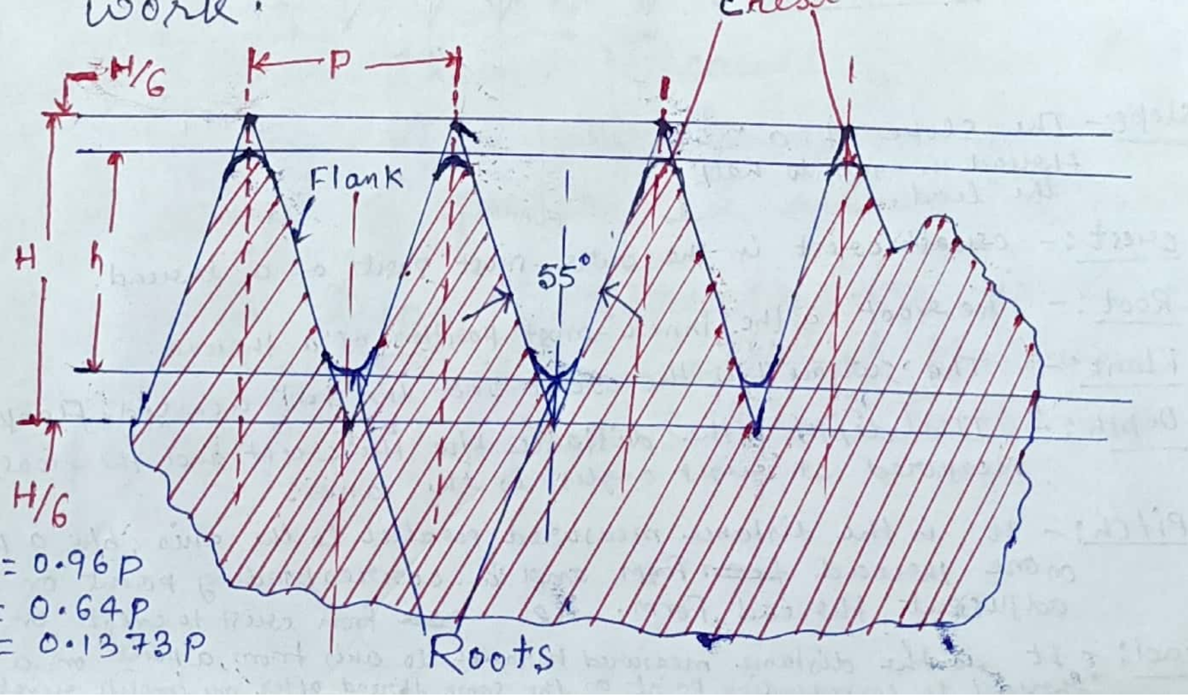
(b) [illegible]

1. British Standards Whitworth (B.S.W) thread.

* This is a British Standard thread profile and has coarse pitches. It is a Symmetrical V-thread in which the angle between the flankes, measured in an axial Plane, is 55°.

* These threads are found on bolts and Screwed fastenings for Special purposes.

British Standard threads with fine pitches (B.S.F) are used where great strength at the root is required. It is used in aero and automobile work.



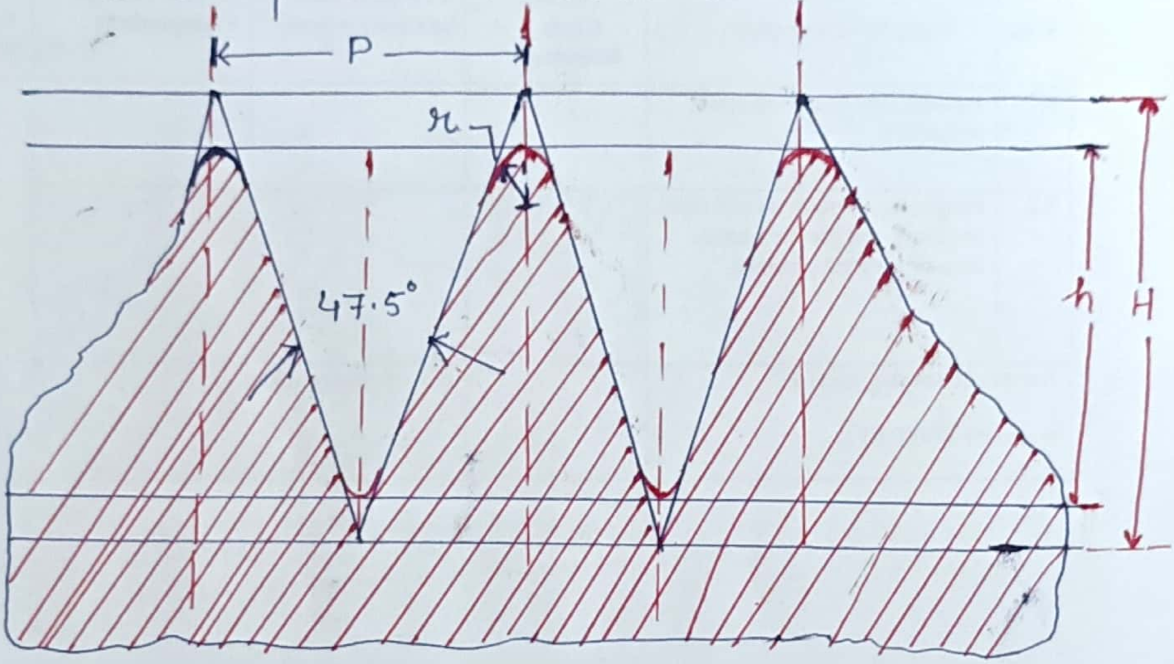
$H = 0.96P$

$h = 0.64P$

$r = 0.1373P$

2. British Association (B.A) thread.

- This is a B.S.W thread with fine pitches. The proportion of B.A thread are shown in fig. ?
- These threads are used for instruments and other precision works.



$H = 1.13634\,P$; $h = 0.6\,P$; $r = 0.18083\,P$

British association (B.A) thread.

3. Square Thread :-

- The Square thread because of their high efficiency, are widely used for transmission of power in either direction.
- Such type of threads are found in the feed mechanisms of Machine tools, Valves, Spindles, Screw Jacks etc.

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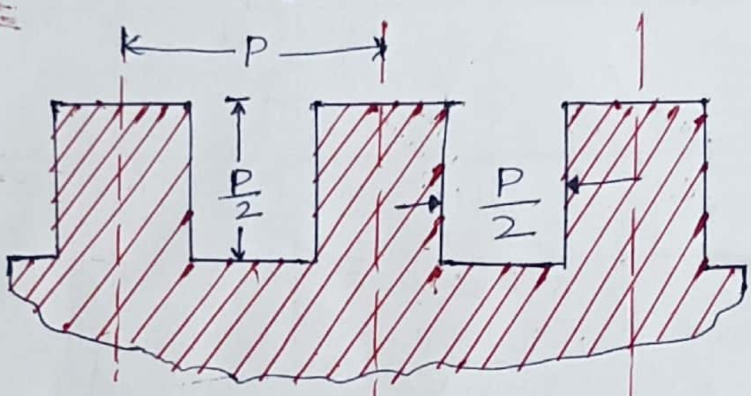
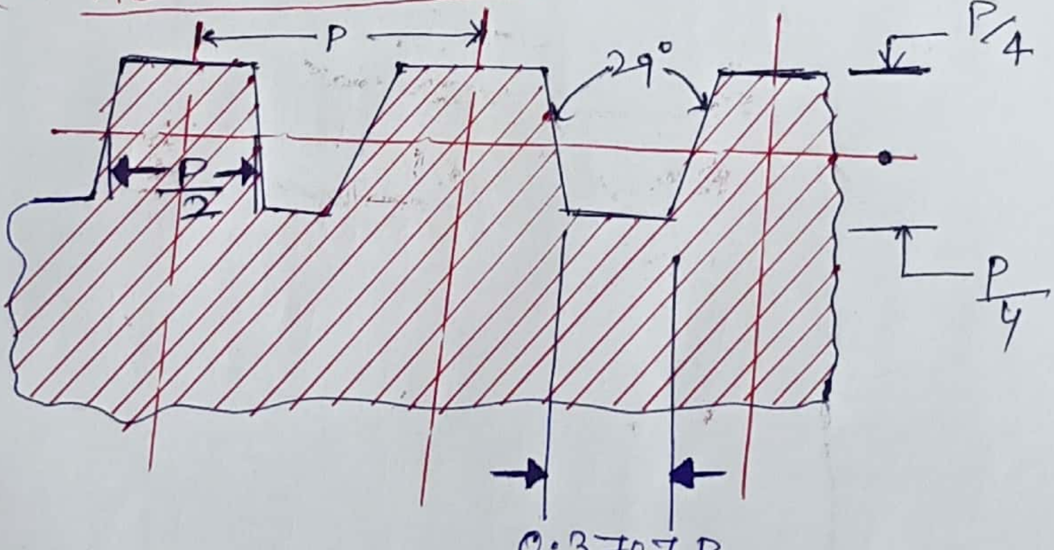
- The Square threads are Not as so strong as V- threads but offer less frictional resistance to motion than whitworth threads.
- The pitch of the square thread is often taken twices that of a B.S.W thread of the Same diameter.



Square thread.

(4) Acme thread :-



- It is a Modification of square thread.
- It is much Stronger than Square thread and Can be Easily produced.
- It is widely used in bench vices, cocks, lathes
- when used in Conjuction with a Split Nut, as the lead Screw of a Lathe, the tapered Sides of the thread facilitate ready engagement & disengagement of Nut

Buttress Thread :-

- It is used for transmission of power in one direction only.
- The force is transmitted almost parallel to the axis.
- This thread units the advantages of both Square and V-threads.
- It has the Low frictional resistance Characteristics of the Square thread and have the Same Strength as that of V-thread.

Metric thread :-

- It is an Indian Standard thread and is similar to B.S.W threads.
- It ~~is~~ has an included angle of 60° instead of 55°.

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Advantages and Disadvantages of Screwed Joints.

Advantages :-

1) Screwed Joints are highly reliable in operation.

2) Screwed Joints are Convenient to assemble and disassemble.

3) A wide range of Screwed Joint may be adopted to various operating Conditions.

4) Screws are relatively cheap to produce due to Standardisation and highly efficient manufacturing processes.

Disadvantage :-

The Stress Concentration in the thread portions which are Vulnerable points under Variable load Conditions.

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UNIT-5

Engine Terminologies.

Definition of I.C Engine and E.C Engine

IC Engine Stands Internal Combustion Engine. In Internal Combustion Engine, the Combustion of fuel in the Presence of air takes place inside the cylinders and products of Combustion directly act on piston to develop the power. Examples of IC Engine Petrol Engine, Diesel Engine.

EC Engine Stands External Combustion Engine. In External Combustion Engine the Combustion takes place outside the Cylinder.

Examples of External Combustion Engine are Steam Turbines, hot air Engines.

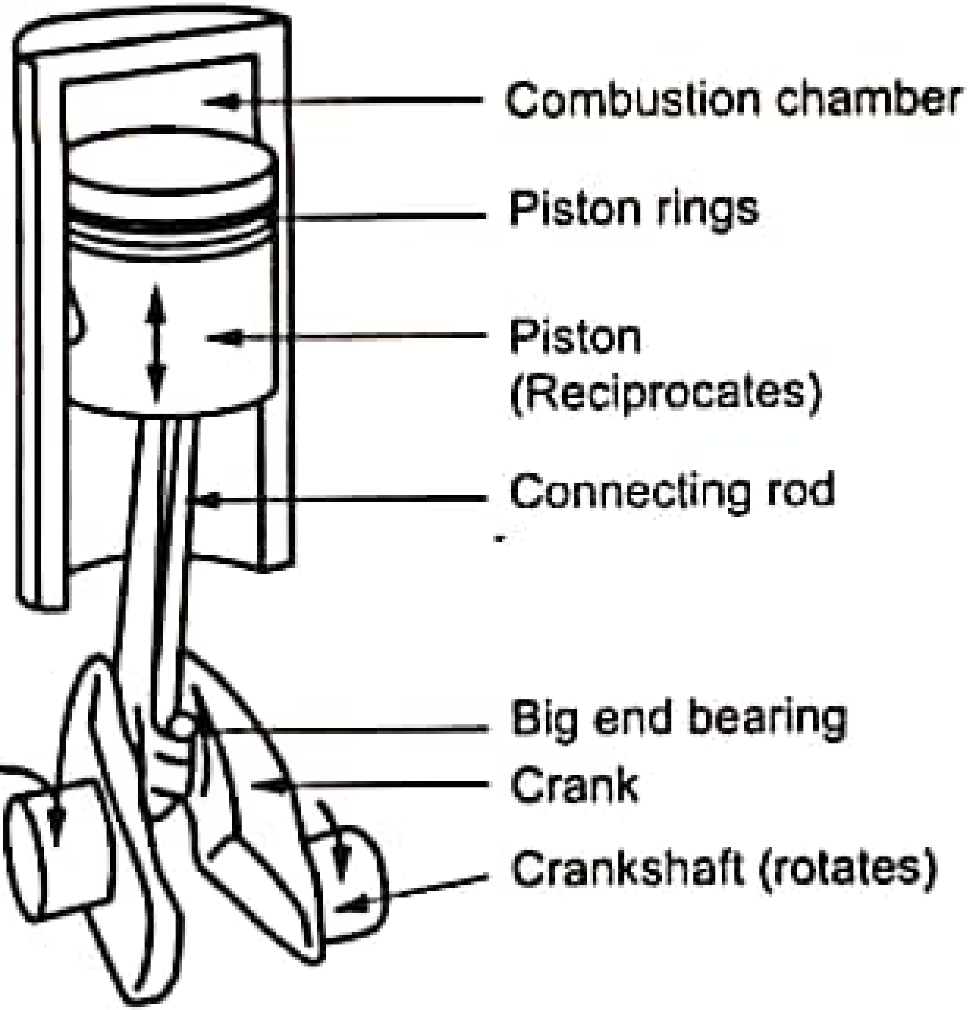
Important Engine Terminologies.

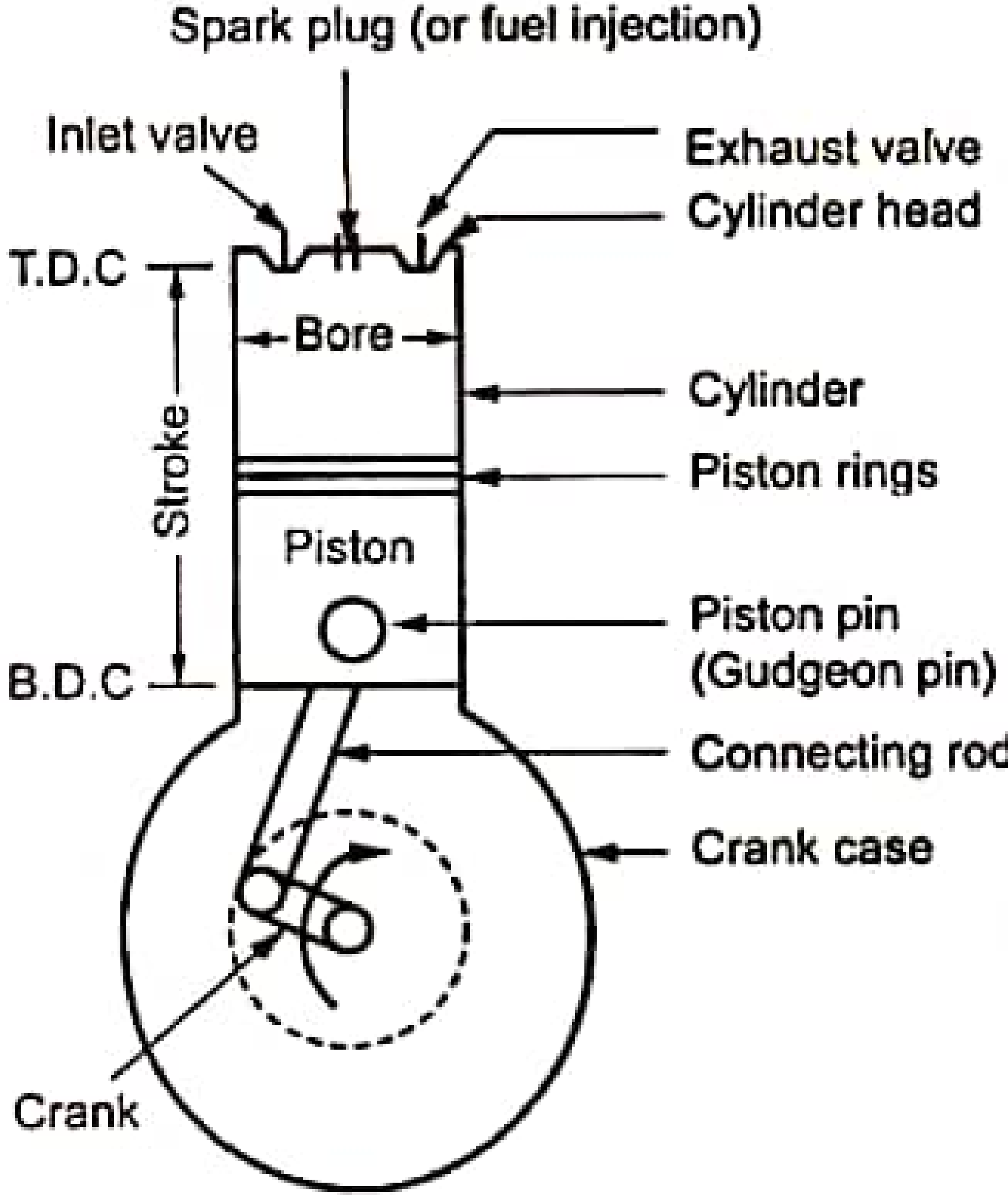
1) Bore (D) : The Inner diameter of the cylinder in which the piston Moves. It is usually measured in Millimeters (mm) or inches.

2) Stroke (L) : The distance traveled by the piston from Top Dead center (TDC) to (BDC) Bottom Dead Center. It determines the displacement volume of the cylinder.

Formula :

Stroke length (L) = 2 × crank radius





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3) Top Dead Center (TDC):

The highest position of the piston ~~is~~ inside the cylinder during its Movement.

4) Bottom dead center (BDC):

The lowest position of the piston inside the cylinder

5) Compression Ratio [CR]:

Compression ratio - The ratio of the Total Cylinder volume (when the piston is at BDC) to the Clearance Volume (when the piston is at TDC).

Significance :- Higher compression ratio improves engine efficiency and fuel Combustion

Formula :-

$$CR = \frac{\text{Total Volume (Swept Volume + Clearance Volume)}}{\text{Clearance Volume}}$$

* A typical Petrol Engine has a CR of 8:1 to 12:1, while a diesel engine has a CR of 14:1 to 23:1.

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Swept Volume :- The volume displaced by the Piston during one Stroke. It depends on the bore and Stroke Length.

Formula :-

$$V_s = \frac{\pi}{4} \times D^2 \times L$$

Clearance volume :- The volume left in the Cylinder when the piston is at TDC. It ensures the proper Combustion of fuel - air Mixtures.

Power of Engine

Indicated Power :- The actual power developed inside the Cylinder is Known as indicated power.

If the net work developed per cycle is considered at constant mean pressure throughout the Stroke of engine, instead of the actual varying pressure then the work done per stroke is given by.

$$W = \text{Force} \times \text{Distance travelled}$$

$$= (\text{Mean pressure} \times \text{area of piston}) \times \text{Stroke of engine}$$

$$= P_m \cdot A \cdot L$$

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If the Number of working Strokes per Second is n, then the I.P given by:

$$I.P = \frac{P_m L A n}{1000} \text{ KW}$$ where, $P_m = N/m^2$, $L = m$ and $A = m^2$.

In single Cylinder Engine
$n = \frac{N}{2}$ for four Stroke engines.

In single Cylinder Engine
$n = N$ for two Stroke Engine.

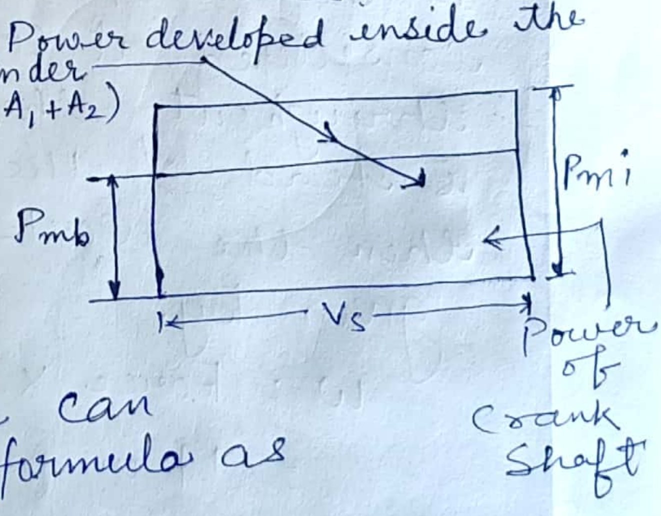
Brake Power :-

$$B.P = I.P - F.P$$

The Net power available at the Crank Shaft or doing useful work is known as Brake power.
The part of the IP lost by different ways as is called Brake power.

Brake Mean effective pressure :-

P_{mb} = ~~Mean~~ Brake Mean effective Pressure
P_{mi} = Indicated Mean effective Pressure



Brake horse power can be given by the formula as follows:-

$$B.P = \frac{P_{mb} L A n}{1000} \text{ KW}$$, Where n is working cycles/sec.

Engine Efficiencies :-

Mechanical Efficiency :-

The ratio of B.P to I.P is Known as Mechanical Efficiencies.

$$\therefore \eta_m = \frac{B.P}{I.P} = \frac{I.P - F.P}{I.P}$$

$$= \frac{B.P}{B.P + F.P}$$

$$\eta_m = \frac{\text{Power available at crank per power Stroke}}{\text{Power developed inside the engine per power Stroke}}.$$

when there is no load on the engine or no useful work is taken from the crankshaft, then B.P = 0, therefore at no load conditions, η_m is zero.

Thermal Efficiency :-

The brake thermal Efficiency is the ratio of B.P (output) to the heat energy of fuel Supplied during the Same interval of time (per hour).

$$\eta_{bt} = \frac{\text{Power developed/hr}}{\text{Energy Supplied/hr}}$$

$$= \frac{B.P\,(\text{in kW}) \times 3600}{m_{fb} \times C.V}$$

Mechanical Science & Engineering – Miscellaneous Questions

(Covering Unit 5: Engine Terminologies)

Short Answer Questions (10 Questions) – 2 Marks Each

1. Define **Internal Combustion (IC) engine** and **External Combustion (EC) engine.**
2. What is the **difference between bore and stroke** in an engine?
3. Define **TDC (Top Dead Center)** and **BDC (Bottom Dead Center).**
4. What do you mean by **compression ratio** in an IC engine?
5. What is **mean effective pressure (MEP)**? How is it significant?
6. Define **brake power (BP)** and **indicated power (IP)**.
7. What is **friction power (FP)**? How is it calculated?
8. Differentiate between **specific fuel consumption (SFC) and thermal efficiency.**
9. Explain the term **engine torque** and its importance in vehicle performance.
10. What are the differences between **thermal efficiency and mechanical efficiency**?

Long Answer Questions (10 Questions) – 5 Marks Each

11. Explain the **main components of an IC engine** with a neat diagram.
12. Compare **two-stroke and four-stroke engines** in terms of efficiency, power, and fuel consumption.
13. What is **compression ratio**? How does it affect engine performance?
14. Derive the relation between **brake power, indicated power, and mechanical efficiency**.
15. Explain **mean effective pressure (MEP)** and its role in determining engine performance.
16. Describe **brake thermal efficiency and indicated thermal efficiency** with their formulas.
17. Explain **engine torque and power** with suitable mathematical expressions.
18. Discuss the effect of **engine speed on fuel consumption and efficiency**.
19. What are the **factors affecting the performance of an IC engine**? Explain in detail.

20. Explain the **methods to measure brake power (BP) and indicated power (IP)** in an engine.

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Unit 6: Internal Combustion (IC) Engines

(Mechanical Science & Engineering – Diploma in Mechanical/Metallurgical Engineering)

6.1 Classification of IC Engines with Respect to Different Parameters

IC (Internal Combustion) engines can be classified based on various parameters:

1. Based on Fuel Used

- **Petrol Engine (SI Engine):** Uses gasoline and operates on the spark ignition principle.
- **Diesel Engine (CI Engine):** Uses diesel fuel and operates on the compression ignition principle.
- **Gas Engines:** Use fuels like CNG, LPG, or biogas.

2. Based on Number of Strokes

- **2-Stroke Engine:** Completes a power cycle in **two strokes** (one revolution of the crankshaft).
- **4-Stroke Engine:** Completes a power cycle in **four strokes** (two revolutions of the crankshaft).

3. Based on Cooling System

- **Air-Cooled Engine:** Uses air and fins for heat dissipation (e.g., motorcycles, scooters).
- **Water-Cooled Engine:** Uses a radiator and coolant to dissipate heat (e.g., cars, trucks).

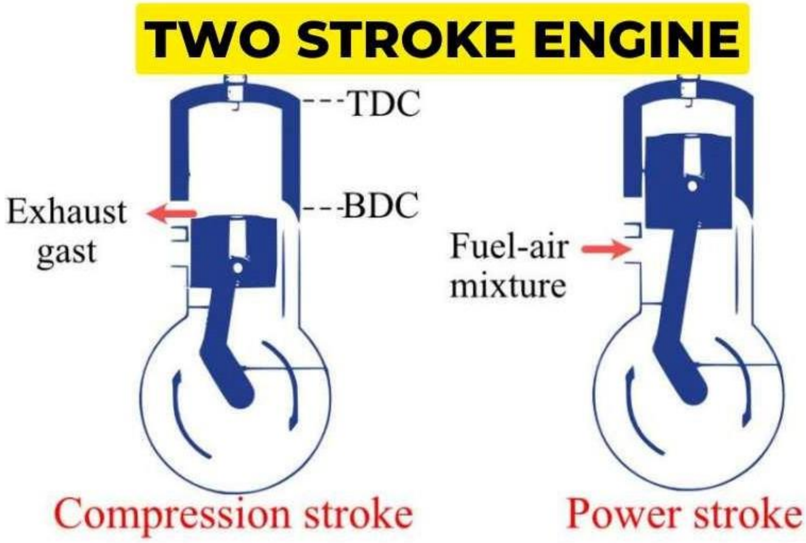
4. Based on Ignition Method

- **Spark Ignition (SI) Engine:** Uses a spark plug for ignition (e.g., petrol engines).
- **Compression Ignition (CI) Engine:** Uses compression of air to ignite fuel (e.g., diesel engines).

5. Based on Cylinder Arrangement

- **Inline Engine:** Cylinders are arranged in a straight line.
- **V-Type Engine:** Cylinders are arranged in a V-shape.
- **Radial Engine:** Cylinders are arranged circularly around the crankshaft.

6.2 Two-Stroke Spark Ignition (SI) Engine – Construction and Working



Construction of a 2-Stroke SI Engine:

A **2-stroke SI engine** consists of:

1. **Cylinder:** Contains the piston and combustion chamber.
2. **Piston:** Moves up and down to compress and expand gases.
3. **Spark Plug:** Ignites the air-fuel mixture.
4. **Crankshaft:** Converts reciprocating motion into rotary motion.
5. **Ports:** Instead of valves, a 2-stroke engine uses **intake, exhaust, and transfer ports**.

Working of a 2-Stroke SI Engine:

A **2-stroke engine completes a power cycle in two strokes of the piston.**

Stroke 1: Compression & Intake Stroke (Upward Motion)

- The **piston moves upward**, compressing the air-fuel mixture inside the cylinder.
- At the same time, fresh air-fuel mixture enters the **crankcase** through the intake port.

Stroke 2: Power & Exhaust Stroke (Downward Motion)

- The **spark plug ignites** the compressed air-fuel mixture, producing an explosion that pushes the piston downward.
- The burnt gases exit through the **exhaust port**, and fresh charge moves into the combustion chamber through the **transfer port**.

🔹 *Used in motorcycles, chainsaws, and marine outboard motors.*

6.3 Four-Stroke Spark Ignition (SI) Engine – Construction and Working

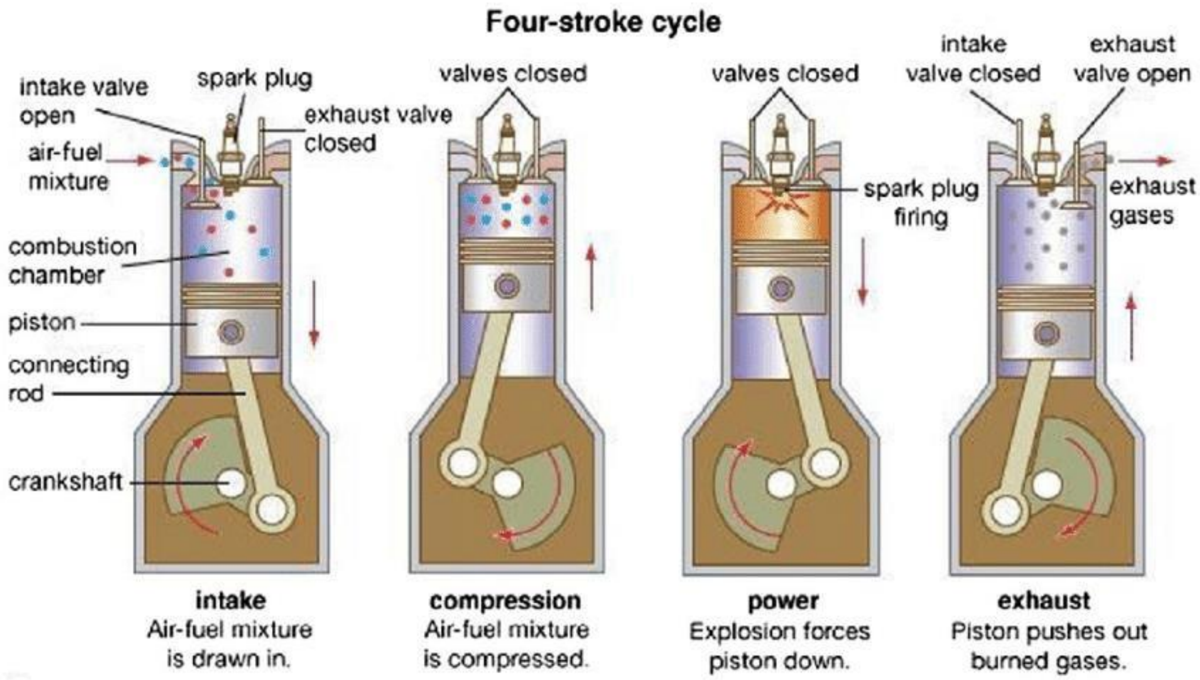
Construction of a 4-Stroke SI Engine:

A **4-stroke petrol engine** consists of:

1. **Cylinder & Piston:** The piston moves inside the cylinder.
2. **Spark Plug:** Generates a spark to ignite the air-fuel mixture.
3. **Valves:** Intake and exhaust valves control gas entry and exit.
4. **Crankshaft & Connecting Rod:** Convert reciprocating motion to rotary motion.

Working of a 4-Stroke SI Engine:

A **4-stroke SI engine completes a power cycle in four strokes.**



Stroke 1: Intake Stroke (Downward Motion)

- The **intake valve opens**, and an **air-fuel mixture** enters the cylinder.
- The piston moves **downward** due to suction.

Stroke 2: Compression Stroke (Upward Motion)

- The **intake valve closes**, and the piston moves **upward**, compressing the mixture.

Stroke 3: Power Stroke (Downward Motion)

- The **spark plug ignites** the compressed mixture, causing an explosion that pushes the piston **downward**.

Stroke 4: Exhaust Stroke (Upward Motion)

- The **exhaust valve opens**, and burnt gases leave the cylinder.
- The piston moves **upward** to expel the gases.

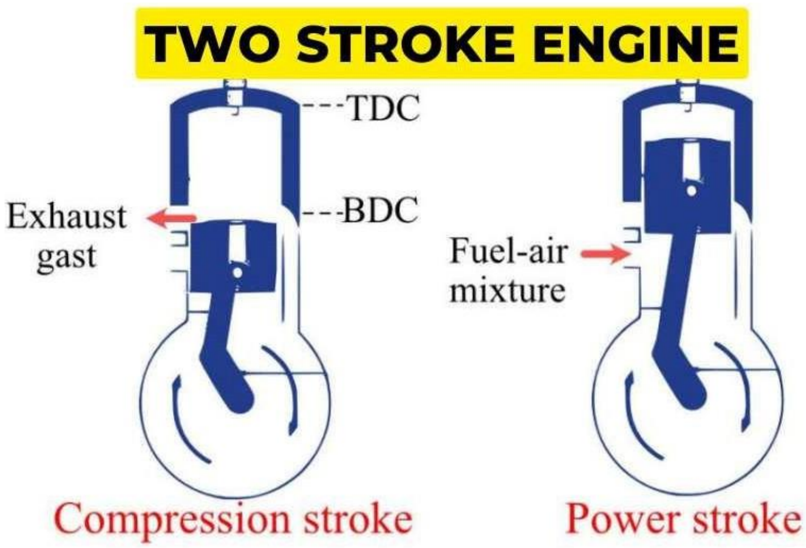
◆ *Used in cars, motorcycles, and generators.*

6.4 Two-Stroke & Four-Stroke Compression Ignition (CI) Engines – Construction & Working

6.4.1 Two-Stroke CI Engine (Diesel Engine)

Construction:

- Similar to a **2-stroke SI engine**, but instead of a **spark plug**, it has a **fuel injector**.



Working:

- **Stroke 1 (Compression Stroke):** The piston moves **upward**, compressing **only air** inside the cylinder.
- **Stroke 2 (Power Stroke):** Diesel fuel is injected, which ignites due to high temperature. The piston moves **downward**.

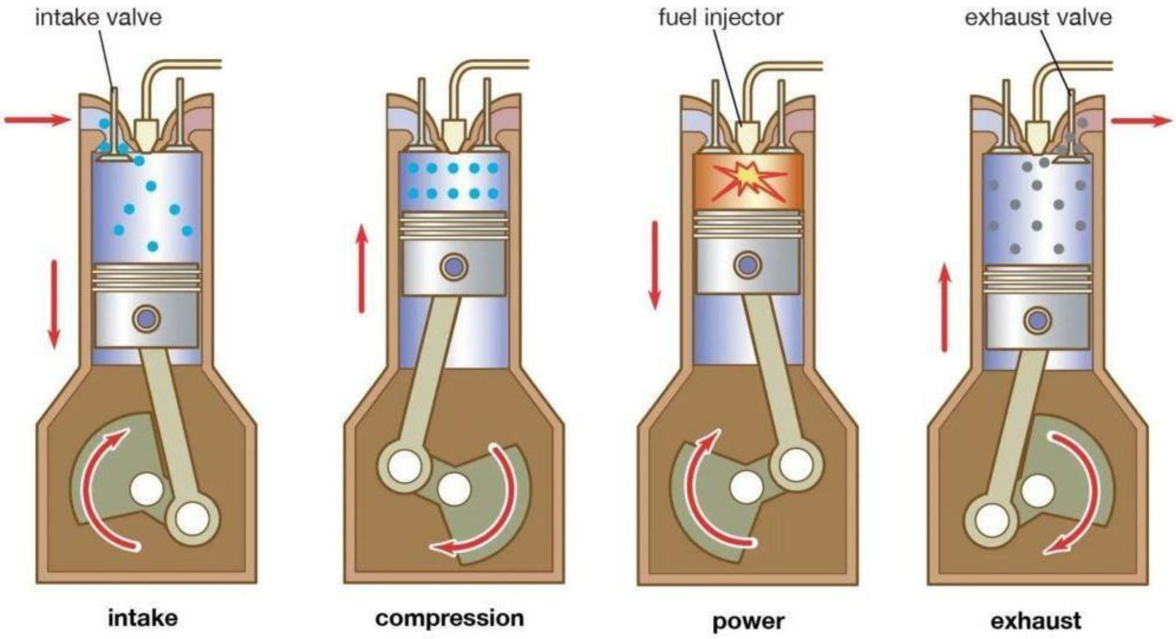
◆ *Used in small diesel generators and marine engines.*

6.4.2 Four-Stroke CI Engine (Diesel Engine)

Construction:

- Similar to a **4-stroke SI engine**, but instead of a **spark plug**, it has a **fuel injector**.

Working:



1. **Intake Stroke:** Only air enters the cylinder.

2. **Compression Stroke:** Air is compressed, increasing temperature.
3. **Power Stroke:** Diesel fuel is injected and ignites due to high temperature.
4. **Exhaust Stroke:** Burnt gases are expelled.

🔹 *Used in trucks, buses, tractors, and industrial engines.*

6.5 Comparison of SI and CI Engines

Feature	SI Engine (Petrol)	CI Engine (Diesel)
Fuel Used	Petrol	Diesel
Ignition Method	Spark Plug Ignition	Compression Ignition
Compression Ratio	6:1 to 12:1	12:1 to 23:1
Fuel Efficiency	Lower	Higher
Cost	Cheaper	More Expensive
Maintenance	Lower	Higher
Applications	Cars, motorcycles	Trucks, buses, tractors

6.6 Comparison of Two-Stroke and Four-Stroke Engines

Feature	2-Stroke Engine	4-Stroke Engine
Power Stroke	Every revolution of the crankshaft	Every two revolutions of the crankshaft
Fuel Efficiency	Less efficient	More efficient
Lubrication	Requires oil mixed with fuel	Uses separate lubrication
Maintenance	Simple and cheaper	Complex and costly
Weight & Size	Lightweight and compact	Heavier and bulkier
Applications	Used in scooters, chainsaws, marine engines	Used in cars, trucks, and power generators

Mechanical Science & Engineering – Miscellaneous Questions

(Covering Unit 6: I.C. Engines)

Short Answer Questions (10 Questions)

1. Define **Internal Combustion (IC) Engine** and **External Combustion (EC) Engine**.
2. What are the **main components of an IC engine**?
3. Differentiate between **2-stroke and 4-stroke engines**.
4. What is the **difference between SI (Spark Ignition) and CI (Compression Ignition) engines**?
5. Define **fuel injection system** in a diesel engine.
6. Explain the function of a **carburetor** in a petrol engine.
7. What is the purpose of a **cooling system** in an IC engine?
8. Differentiate between **wet sump and dry sump lubrication systems**.
9. What is the function of a **flywheel** in an engine?
10. What is **supercharging**, and how does it improve engine performance?

Long Answer Questions (10 Questions)

11. Explain the **working principle of a 4-stroke SI (Petrol) engine** with a neat diagram.
12. Explain the **working principle of a 4-stroke CI (Diesel) engine** with a neat diagram.
13. Compare the **2-stroke engine and 4-stroke engine** based on construction, efficiency, and applications.
14. Describe the **fuel supply system in a petrol engine** with a neat sketch.
15. Explain the **working of a cooling system** in an IC engine and its different types.
16. What are the **different types of lubrication systems** used in IC engines? Explain with diagrams.
17. Explain the **working and importance of a fuel injection system** in a diesel engine.
18. What is **supercharging and turbocharging**? Explain their effects on engine performance.
19. Discuss the **emission control techniques** used in modern IC engines.

Mechanical Science & Engineering – Miscellaneous Questions

(Covering Unit 1: Engineering Materials and Their Properties)

Short Answer Questions (10 Questions)

1. Define engineering materials and classify them into different types.
2. What are the physical and mechanical properties of metals?
3. Explain the difference between **ductility** and **malleability** with examples.
4. What is **alloy steel**? Name two alloying elements and their effects on steel.
5. Define **ferrous metals** and **non-ferrous metals** with suitable examples.
6. What is cast iron? List its types and one application of each.
7. Why is stainless steel corrosion-resistant? Mention its major composition.
8. Differentiate between annealing and normalizing heat treatment processes.
9. What is **tempering**? Why is it necessary after hardening?
10. Define **hardness, toughness, and tensile strength** with examples.

Long Answer Questions (10 Questions)

11. Explain the classification of engineering materials based on their properties and applications.
12. Compare **mild steel, medium carbon steel, and high carbon steel** based on composition, properties, and applications.
13. Describe the **heat treatment process** and explain the following with diagrams:

- Annealing
- Hardening

14. What is **hardenability**? How does it affect the performance of metals in engineering applications?
15. Discuss the applications of **aluminium alloys and copper alloys** in the engineering industry.
16. Explain the importance of material selection in mechanical engineering with examples.
17. Discuss the effects of **carbon content** on the properties of steel.

18. What is **nitriding**? How is it different from carburizing? Explain their industrial applications.
19. Explain the **different types of cast iron** and their engineering applications.
20. Write a short note on **composite materials** and their advantages in modern engineering applications.

Mechanical Science & Engineering – Miscellaneous Questions

(Covering Unit 2: Shafts, Keys, Couplings, and Bearings)

Short Answer Questions (10 Questions)

1. Define **shaft** and mention its common applications.
2. What are the **different types of shafts** used in mechanical systems?
3. Define **keys** and explain their function in power transmission.
4. What is a **coupling**? Why is it used in mechanical engineering?
5. Differentiate between **rigid coupling** and **flexible coupling**.
6. Define **bearings** and mention their primary function in machinery.
7. What are the materials commonly used for manufacturing shafts?
8. Explain the difference between **sunk key** and **saddle key**.
9. What is a **ball bearing**? Mention two applications.
10. What is the purpose of **splines** in shafts?

Long Answer Questions (10 Questions)

11. Explain the **classification of shafts** and their applications in power transmission.
12. Describe the different **types of keys** used in mechanical engineering with neat sketches.
13. Explain the **working principle of flange coupling** with a label diagram.
14. What are **different types of bearings**? Explain **sliding contact bearings** and **rolling contact bearings** with examples.
15. Explain **the requirements of a good shaft coupling** and describe two common types.
16. Discuss the **advantages and disadvantages of ball bearings and roller bearings**.
17. Explain the **procedure for selecting a shaft material** for a specific engineering application.
18. What are the **common causes of bearing failure**, and how can they be prevented?
19. Explain the construction and working of a **roller bearing** with a neat diagram.

20. Compare **muff coupling, clamp coupling, and flange coupling** with their specific applications.

Mechanical Science & Engineering – Miscellaneous Questions

(Covering Unit 3: Belt Drives, Chain Drives, and Gear Drives)

Short Answer Questions (10 Questions) – 2 Marks Each

1. Define **belt drive** and mention its applications.
2. What is **velocity ratio** in a belt drive? Write its formula.
3. Compare **open belt drive** and **crossed belt drive**.
4. What is **slip and creep** in belt drives? How do they affect performance?
5. Mention two **advantages** and two **disadvantages** of **V-belt drives**.
6. Define **gear train** and explain its significance.
7. Differentiate between **simple gear train** and **compound gear train**.
8. What is a **chain drive**? Where is it commonly used?
9. Compare **gear drive** and **chain drive** based on power transmission.
10. What are the types of gears used in mechanical systems? Name any four.

Long Answer Questions (10 Questions) – 5 Marks Each

11. Explain the **different types of belt drives** with neat sketches.
12. Derive the **velocity ratio formula** for a belt drive and explain its significance.
13. Explain **V-belt drive** with a diagram. Compare it with a **flat belt drive**.
14. What are the **common problems in belt drives**? How can they be prevented?
15. Describe **gear terminology** with a neat sketch.
16. Explain **the working of a compound gear train** with an example.
17. What are the **advantages and disadvantages of gear drives** over belt and chain drives?
18. Explain **different types of chains** used in mechanical applications and compare them with belts.
19. Differentiate between **spur gears, helical gears, and bevel gears** with their applications.
20. Explain **worm and worm wheel** drive with a neat diagram. Mention its applications.

Mechanical Science & Engineering – Miscellaneous Questions

(Covering Unit 4: Fasteners)

Short Answer Questions (10 Questions)

1. Define **fasteners** and classify them into **temporary** and **permanent** types.
2. What are **screw threads**? Mention their main functions.
3. Differentiate between **bolt, screw, and stud**.
4. What is the difference between **left-hand and right-hand threads**?
5. Name and explain two **locking devices** used in mechanical fasteners.
6. What are **set screws**? Where are they used?
7. Differentiate between **riveted joints** and **welded joints**.
8. What is a **lap joint**? Where is it commonly used?
9. Define **pitch, lead, and crest** in screw threads.
10. What are **cotter joints**? Give one application.

Long Answer Questions (10 Questions)

11. Explain the **types of screw threads** with neat sketches.
12. Describe different **types of bolts** used in mechanical applications.
13. Compare **temporary and permanent fasteners** with examples.
14. Explain different **types of locking devices** with neat sketches.
15. What are **different types of riveted joints**? Explain with diagrams.
16. Describe the **construction and working of a cotter joint** with a neat diagram.
17. Compare **butt joint and lap joint** with proper diagrams and applications.
18. Explain **self-locking of screw threads** and its significance.
19. What is **power screw**? Describe its applications in mechanical engineering.
20. Explain **keys, cotters, and pins** used in fastening mechanical components.

Mechanical Science & Engineering – Miscellaneous Questions

(Covering Unit 5: Engine Terminologies)

Short Answer Questions (10 Questions) – 2 Marks Each

1. Define **Internal Combustion (IC) engine** and **External Combustion (EC) engine**.
2. What is the **difference between bore and stroke** in an engine?
3. Define **TDC (Top Dead Center)** and **BDC (Bottom Dead Center)**.
4. What do you mean by **compression ratio** in an IC engine?
5. What is **mean effective pressure (MEP)**? How is it significant?
6. Define **brake power (BP)** and **indicated power (IP)**.
7. What is **friction power (FP)**? How is it calculated?
8. Differentiate between **specific fuel consumption (SFC) and thermal efficiency**.
9. Explain the term **engine torque** and its importance in vehicle performance.
10. What are the differences between **thermal efficiency and mechanical efficiency**?

Long Answer Questions (10 Questions) – 5 Marks Each

11. Explain the **main components of an IC engine** with a neat diagram.
12. Compare **two-stroke and four-stroke engines** in terms of efficiency, power, and fuel consumption.
13. What is **compression ratio**? How does it affect engine performance?
14. Derive the relation between **brake power, indicated power, and mechanical efficiency**.
15. Explain **mean effective pressure (MEP)** and its role in determining engine performance.
16. Describe **brake thermal efficiency and indicated thermal efficiency** with their formulas.
17. Explain **engine torque and power** with suitable mathematical expressions.
18. Discuss the effect of **engine speed on fuel consumption and efficiency**.
19. What are the **factors affecting the performance of an IC engine**? Explain in detail.

20. Explain the **methods to measure brake power (BP) and indicated power (IP)** in an engine.

Mechanical Science & Engineering – Miscellaneous Questions

(Covering Unit 6: I.C. Engines)

Short Answer Questions (10 Questions)

1. Define **Internal Combustion (IC) Engine** and **External Combustion (EC) Engine**.
2. What are the **main components of an IC engine**?
3. Differentiate between **2-stroke and 4-stroke engines**.
4. What is the **difference between SI (Spark Ignition) and CI (Compression Ignition) engines**?
5. Define **fuel injection system** in a diesel engine.
6. Explain the function of a **carburetor** in a petrol engine.
7. What is the purpose of a **cooling system** in an IC engine?
8. Differentiate between **wet sump and dry sump lubrication systems**.
9. What is the function of a **flywheel** in an engine?
10. What is **supercharging**, and how does it improve engine performance?

Long Answer Questions (10 Questions)

11. Explain the **working principle of a 4-stroke SI (Petrol) engine** with a neat diagram.
12. Explain the **working principle of a 4-stroke CI (Diesel) engine** with a neat diagram.
13. Compare the **2-stroke engine and 4-stroke engine** based on construction, efficiency, and applications.
14. Describe the **fuel supply system in a petrol engine** with a neat sketch.
15. Explain the **working of a cooling system** in an IC engine and its different types.
16. What are the **different types of lubrication systems** used in IC engines? Explain with diagrams.
17. Explain the **working and importance of a fuel injection system** in a diesel engine.
18. What is **supercharging and turbocharging**? Explain their effects on engine performance.
19. Discuss the **emission control techniques** used in modern IC engines.

20. Explain the **importance of engine testing** and list different performance parameters measured during testing.