# BUDDHA SERIES

## (Unit Wise Solved Question & Answers)

## Course – B.Tech

## College – Buddha Institute of Technology

**(AKTU CODE-525)**

## Department: ASH 1

## Subject: Fundamental of Mechanical Engineering (BME101)

## Faculty Name: Mohd Faizan / S .B lal

## Unit - 1

# Unit – I

## Introduction to Mechanics of Solid

**SYLLABUS:**

Normal and shear Stress, strain, Hooke's law, Poisson's ratio, elastic constants and their relationship, stress-strain diagram for ductile and brittle materials, factor of safety.

Types of beams under various loads, Statically Determinate Beams, Shear force and bending moment in beams, Shear force and bending moment diagrams, Relationships between load, shear and bending moment.

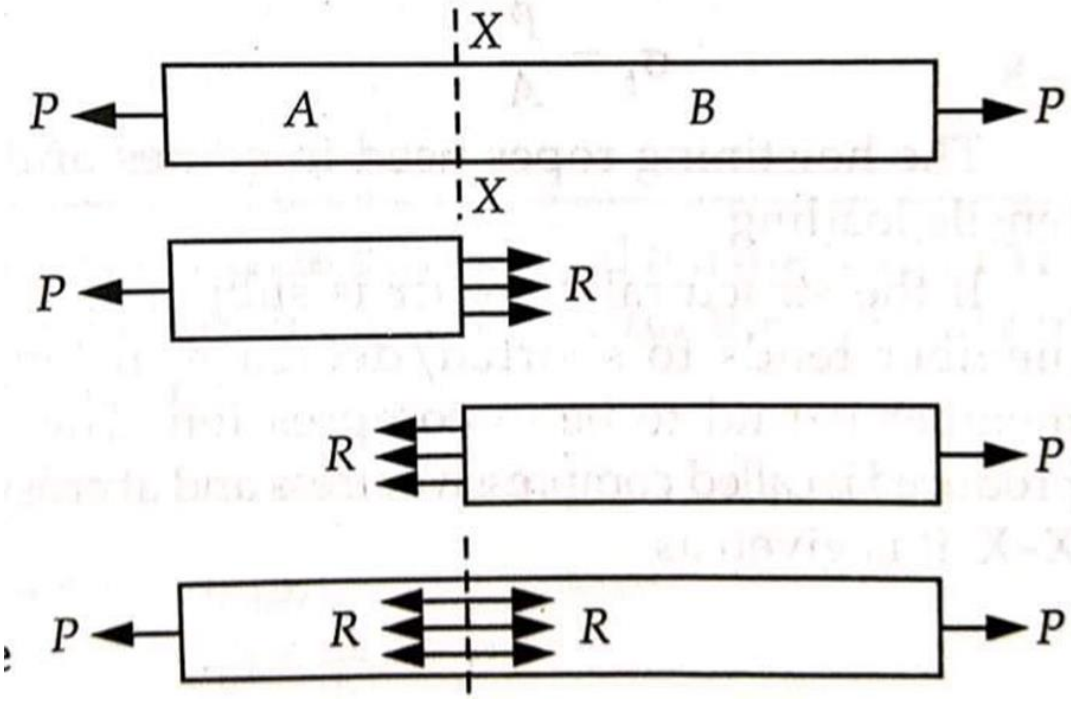
**Basic Numerical problems:**

**Q .1 Define Stress? (V.Imp)**

**Ans:** Stress is defined as the internal resisting force per unit cross-sectional area.

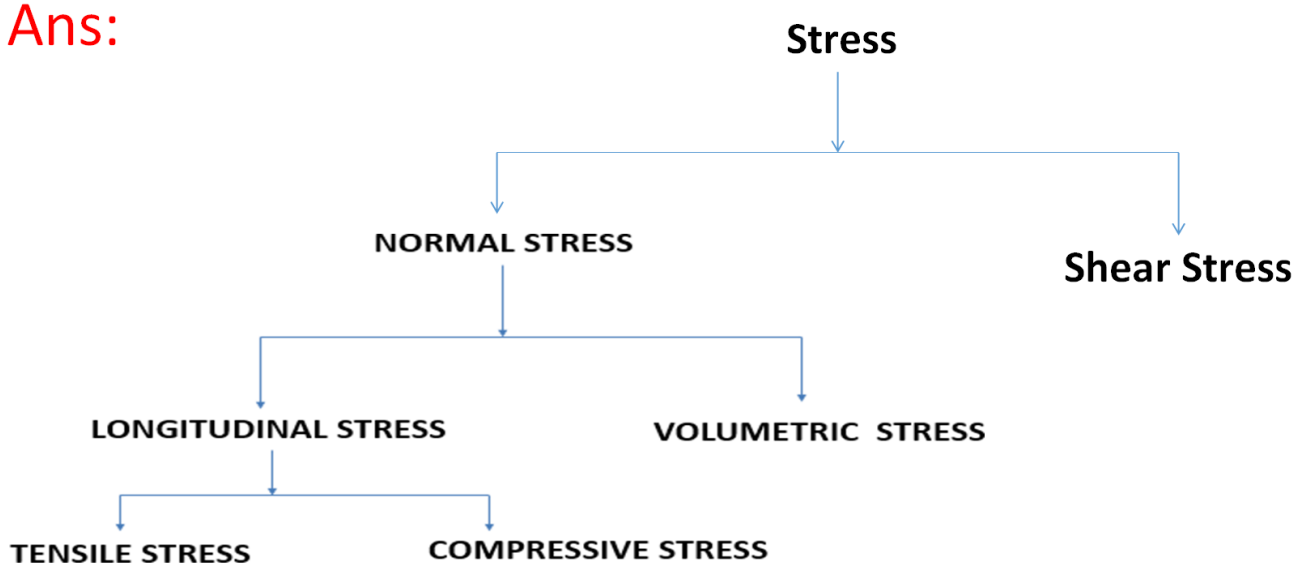
$$\sigma = \frac{R}{A} = \frac{P}{A}$$

**Unit- $N/m^2$**



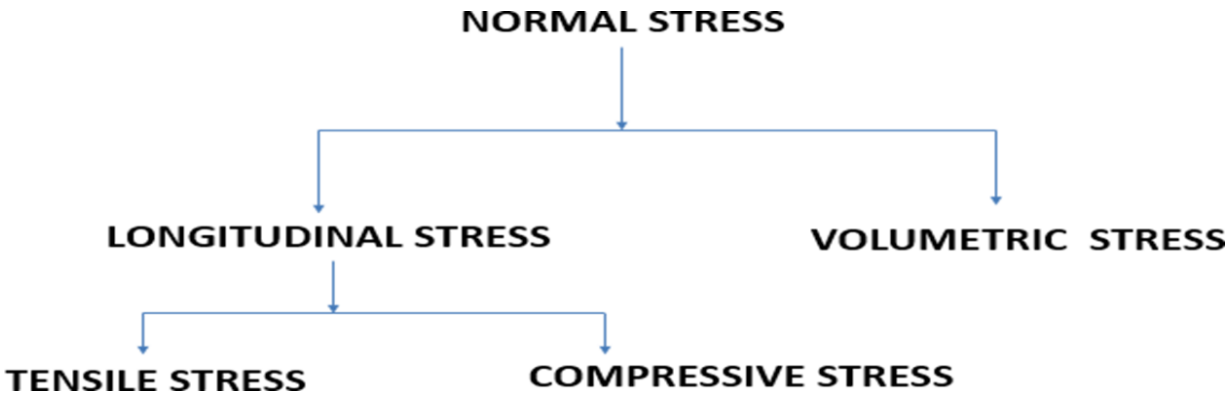
**Q.2 What are the types of Stress?**

Ans:



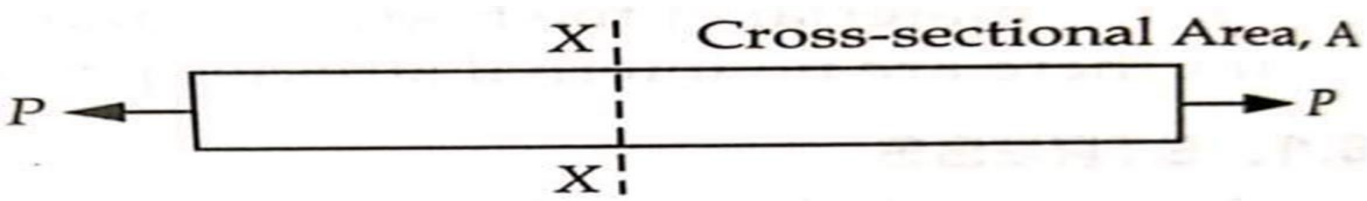

**Q.3 What is Normal Stress? (V.Imp)**

**Ans** : Stress is said to be Normal stress when the direction of the deforming force is perpendicular to the cross-sectional area of the body.



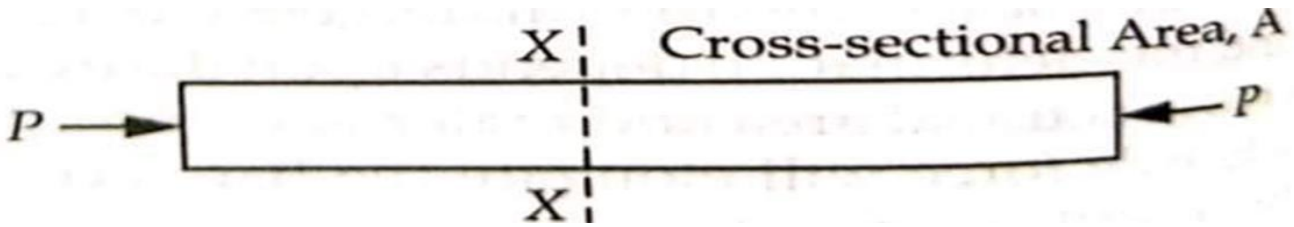

**Q.4 Define Tensile and Compressive Stress.**

Ans **:** When a structural member is subjected to two equal and opposite tensile forces, the stress produced is called tensile stress. The tensile stress at ***P***any cross-section X-X is given as $\boldsymbol{\sigma t}$ = A.




**Compressive Stress($\boldsymbol{\sigma c}$):**

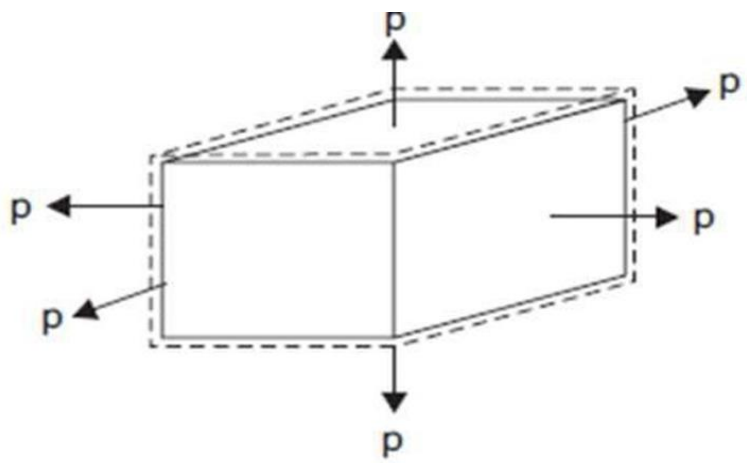
When a structural member is subjected to two equal and opposite compressive forces, the stress produced is called compressive stress. The ***P*** compressive stress at any cross-section X-X is given as $\boldsymbol{\sigma c}$ = A.




**Q .5 Define Volumetric Stress.**

**Ans:** When the deforming force or applied force acts from all dimension resulting in the change of volume of the object then such stress in called volumetric stress or Bulk stress.

In short, when the volume of body changes due to the deforming force it is termed as Volume stress.




**Q.6 Define Shear Stress. (V.Imp)**

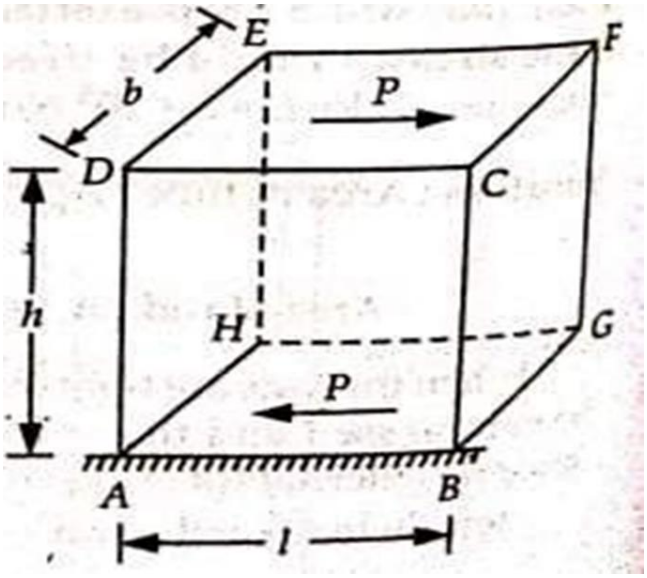
**Ans:** Stress produced by a force tangential to the surface of a body is known as shear stress.

1. It is represented by τ.
2. Consider a rectangular

ABCD fixedat the bottom plane and subjected to tangential force P at the upper plane. Then

$$\text{shear stress } \tau = \frac{\text{tangential force}}{\text{area of face } DCFE}$$

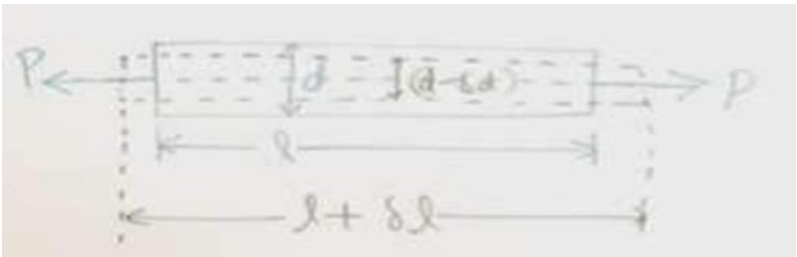
$$= \frac{P}{bl}$$




**Q.7 What is strain? (V.Imp)**

**Ans:** A body is said be strained when the relative position of the particles is changed due to loads acting on the member.

1. This is **deformation per unit original length.**
2. It can be defined as the ratio of change in dimension and original dimension.

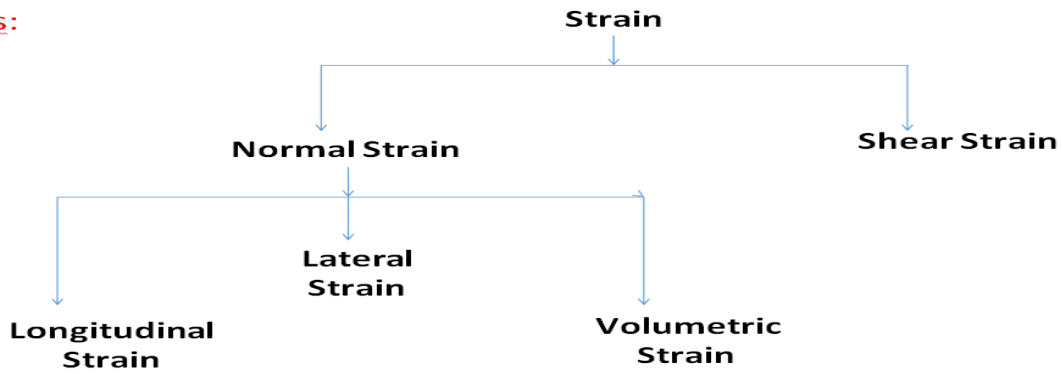



$$Strain = \frac{change\ in\ dimension}{original\ dimension},$$

**Note:** Strain is dimensionless quantity.

**Q .8 What are the types of strain?**

Ans:

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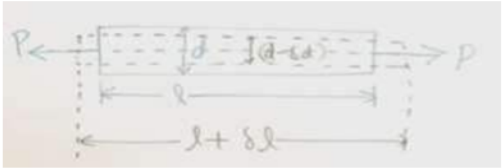
## Q.9 What is the difference between Longitudinal strain and Lateral strain?

Ans: Strain **in the direction** of applied load is called **primary strain** or **longitudinal strain** or **linear strain.**



$$\text{longitudinal } strain = \frac{change\ in\ length}{original\ length}, \qquad s_{long} = \frac{\delta l}{l}$$

❖Strain in the **perpendicular** direction of applied load is called lateral strain.

$$\text{lateral } strain = \frac{change\ in\ diameter}{original\ diameter}, \qquad s_{lat} = \frac{\delta d}{d}$$

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## Q.10 Explain Volumetric Strain.

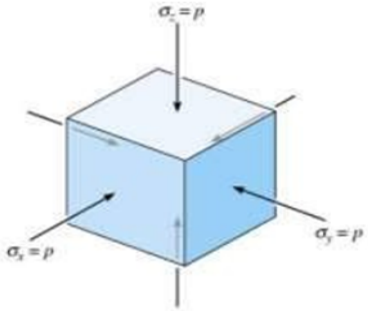
**Ans:** When a body is immersed in a fluid to a large depth, the body is subjected to equal external pressure at all points on the body.

❖Due to this external pressure, stress is produced within the body which is called hydrostatic stress.

❖This external pressure causes change in volume of the body.

❖This change in volume per unit volume is called volumetric strain, $s_v$.

$$s_V = \frac{change\ in\ volume}{Original\ volume} = \frac{\delta V}{V}$$



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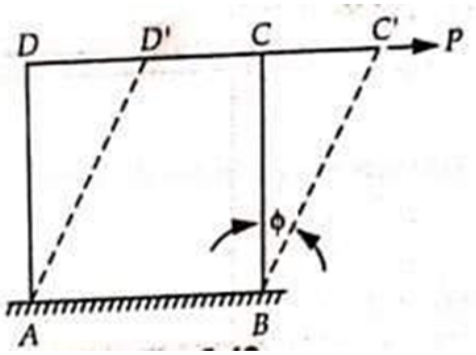
## Q.11 Define Shear Strain.

**Ans: Strain produced by a force tangential to the surface of a body is known as Shear strain.**

Under the action of tangential force, the block ABCD gets distorted and takes the shape ABC'D' by deforming through an angle ϕ.

$$\tan \phi = \phi = \frac{CC'}{BC}$$

The angular deformation ϕ in radians represents the shear strain.

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## Q .12 State the Hooke's Law. (V.Imp)

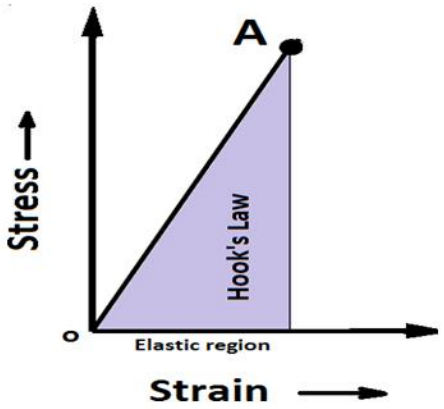
**Ans:** Hooke's law states that when a material is loaded within proportional limit, stress is directly proportional to strain,

Mathematically

$$\text{Stress} \propto \text{strain} \; ; \quad \sigma \propto \varepsilon$$

$$\text{Stress} = \text{constant of proportionality} \times \text{strain}$$

or $$\sigma = E \; \varepsilon \; ; \quad E = \frac{\sigma}{\varepsilon} = \frac{\text{stress}}{\text{strain}}$$




Where the constant of proportionality E is called Young's modulus or modulus of elasticity.

$$E = \frac{\sigma}{\varepsilon} = \frac{\text{stress}}{\text{strain}}$$

Unit of Young's modulus is same as unit of stress because strain is dimensionless quantity.

**N/m2, Pa, Kpa, Mpa, Gpa**

E is a property of the material:

| Material | Steel | Cast iron | Aluminium | Brass | Bronze |
|---|---|---|---|---|---|
| E, GPa | 200–210 | 100–110 | 68–70 | 100–110 | 110–120 |

**Q .13 What is the expression for elongation or contraction in a bar when it subjected to external load P.**

**Ans:**

Recalling that $\varepsilon = \frac{\delta l}{l}$ and $\sigma = \frac{P}{A}$, we get

$$\frac{P}{A} = E\,\varepsilon = E\,\frac{\delta l}{l}$$

$$\text{Change in length } \delta l = \frac{\sigma l}{E} = \frac{Pl}{AE}$$

**Q .14 How many no. of elastic constants are there.**

**Ans:** For homogenous and isotropic material no. of elastic constants are 4(μ, E, G, K).

1) Poisson's Ratio(μ)
2) Modulus Of Elasticity or Young's modulus(E)
3) Modulus Of Rigidity or Shear Modulus(G)
4) Bulk Modulus(K)

**Elastic constants**

1. are used to determine strain theoretically.
2. are used obtain relationship between stress and strain.

**Q.15 Define Poisson's Ratio. (V.Imp)**

**Ans:** It is defined as the ratio of lateral strain to longitudinal strain.

$$\text{Poisson's Ratio}(\mu) = \frac{Lateral\ strain}{Longitudinal\ strain}$$

**Poisson's ratio is dimensionless.**

The value of μ lies between 0.25 to 0.33 for most of the engineering materials.

## Q.16 Define Modulus Of Elasticity or Young's Modulus. (V.Imp.)

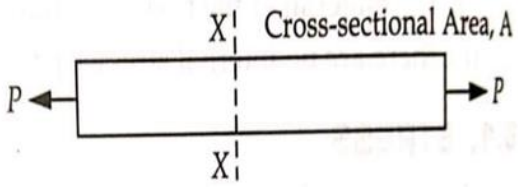
**Ans:** It is defined as the ratio of **normal stress** and **normal strain**, when material is loaded within elastic limit.

$$E = \frac{\sigma}{\varepsilon} = \frac{\text{stress}}{\text{strain}}$$

❖ Unit of Young's modulus is same as unit of stress because strain is dimensionless quantity.

**N/m², Pa, Kpa, Mpa, Gpa**

E is a property of the material.




| Material | Steel | Cast iron | Aluminium | Brass | Bronze |
|---|---|---|---|---|---|
| E, GPa | 200–210 | 100–110 | 68–70 | 100–110 | 110–120 |

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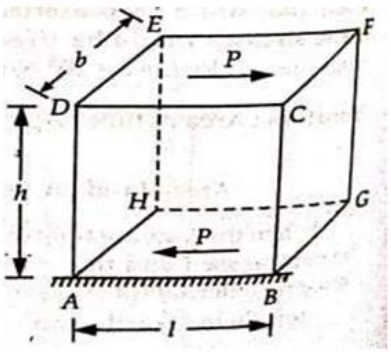
## Q.17 Define Modulus Of Rigidity or Shear Modulus. (V.Imp.)

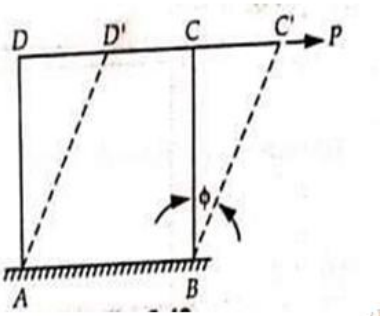
**Ans:** It is defined as the ratio of **shear stress** and **shear strain**, when material is loaded within elastic limit.

$$G = \frac{\textit{Shear Stress}}{\textit{Shear Strain}} = \frac{\tau}{\phi}$$




❖ Unit of shear modulus is same as unit of stress because strain is dimensionless quantity.

**N/m², Pa, Kpa, Mpa, Gpa**



**Q.18 Define Bulk Modulus. (V.Imp.)**

**Ans:** It is defined as the ratio of **volumetric stress** and **volumetric strain**, when material is loaded within elastic limit.

$$K = \frac{Volumetric\ Stress}{Volumetric\ Strain} = \frac{\sigma_v}{s_v}$$

❖Unit of Bulk modulus is same as unit of stress because strain is dimensionless quantity.

**$N/m^2$, Pa, Kpa, Mpa, Gpa**

**Q .19 What is the relation between, E, K and μ ?**

**Ans: E = 3K (1-2μ)**

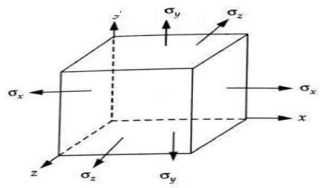
where E is modulus of elasticity, K is bulk modulus and μ is Poisson's ratio.

Proof that E = 3K (1-2μ), where E is modulus of elasticity, K is bulk modulus and μ is Poisson's ratio. (V.Imp.)

Consider a cubical element subjected to volumetricstress which acts simultaneously along mutually perpendicular x , y and z direction.

$\varepsilon_x$ = strain in $x$-direction due to $\sigma_x$ – strain in $x$-direction due to $\sigma_y$ – strain in $x$-direction due to $\sigma_z$

$$= \frac{\sigma_x}{E} - \mu\frac{\sigma_y}{E} - \mu\frac{\sigma_z}{E}$$



But $\sigma_x = \sigma_y = \sigma_z = \sigma$

$$\therefore \quad \varepsilon_x = \frac{\sigma}{E} - \mu\frac{\sigma}{E} - \mu\frac{\sigma}{E} = \frac{\sigma}{E}(1 - 2\mu)$$

Likewise $\varepsilon_y = \frac{\sigma}{E}(1 - 2\mu)$ and $\varepsilon_z = \frac{\sigma}{E}(1 - 2\mu)$

Volumetric strain $\varepsilon_v = \varepsilon_x + \varepsilon_y + \varepsilon_z = \frac{3\sigma}{E}(1 - 2\mu)$

Now, bulk modulus $K = \frac{\text{volumetric stress}}{\text{volumetric strain}} = \frac{\sigma}{\frac{3\sigma}{E}(1 - 2\mu)} = \frac{E}{3(1 - 2\mu)}$

$$\therefore \quad E = 3K(1 - 2\mu)$$

## Q .20 What is the relation between, E, G and μ ?

**Ans: E = 2G (1 + μ)**

Where E is modulus of elasticity, G is shear modulus and μ is Poisson's ratio.

Proof that E = 2G (1+μ), where E is modulus of elasticity, G is modulus of rigidity and μ is Poisson's ratio. (V.Imp.)

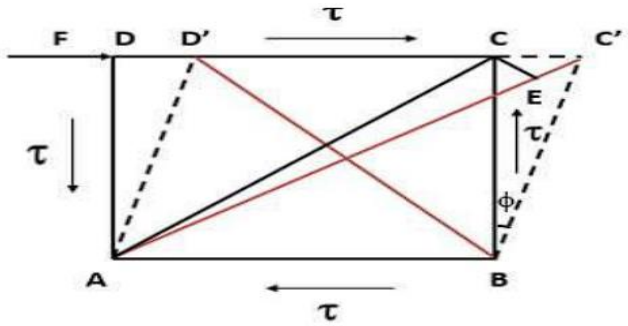
Consider a cubic element ABCD

**When the block is subjected to tangential force it distorts to a new shape ABC'D'.**

Longitudinal stain in diagonal AC

$$= \frac{AC'-AC}{AC} = \frac{AC'-AE}{AC}$$

$$\frac{EC'}{AC}$$




Extension CC' is very small , ∠AC'B is assumed to be equal to ∠ACB =45 Degree.

EC' = CC' COS 45

= CC'/ √2

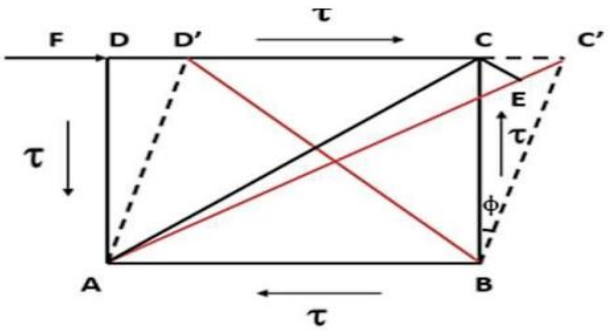
$$\text{Longitudinal Strain} = \frac{CC'}{\sqrt{2}\,AC} = \frac{CC'}{\sqrt{2}\,\sqrt{2}\,BC} = \frac{CC'}{2\,BC}$$

rom triangle BCC'

$$\tan\phi = \frac{CC'}{BC}$$

$$\text{Longitudinal Strain} = \frac{\tan\phi}{2} = \frac{\phi}{2}$$

Where ϕ represents the shear strain.




In terms of shear stress τ and modulus of rigidity G

Shear strain(ϕ) = τ/G

Longitudinal stain for diagonal AC = τ/2G

The strain in diagonal AC is also given by =

Strain due to tensile stress in AC – strain due to compressive stress in BD

**Note: In case of pure shear stress (σ = τ)**

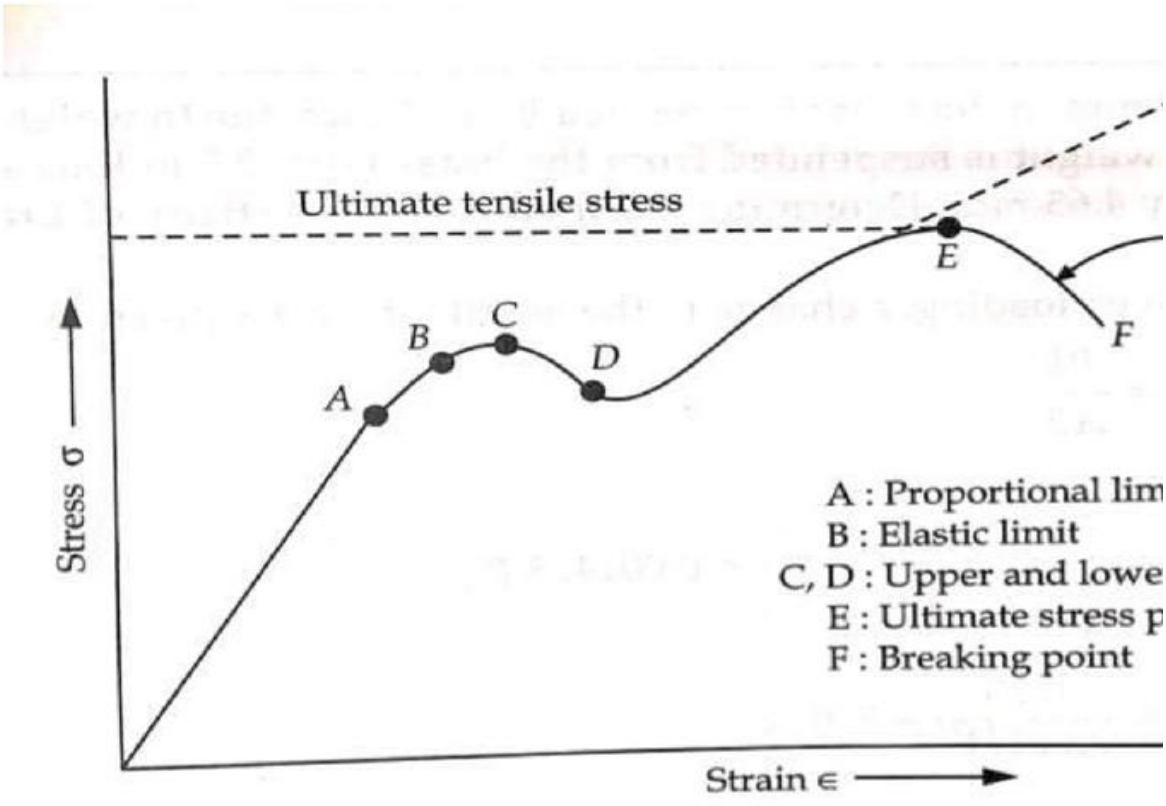
$$= \frac{\tau}{E} - \left(-\mu\frac{\tau}{E}\right) = \frac{\tau}{E}(1+\mu)$$

$$\tau/2G = \frac{\tau}{E}(1+\mu)$$

$$E = 2G(1+\mu)$$

**Q.21 Draw stress-strain diagram for mild steel. (V.Imp.)**

**Ans:**




❖ **Proportional limit(A):**

- Upto this limit, stress is a linear function of strain and material obeys Hook's law.
- **0-A** is a straight line of the curve and its slope represents the value of modulus of elasticity.

❖ **Elastic limit(B):**

- It represents maximum stress upto which material is still able to regain its original shape and size after removal of load i.e. upto this point deformation is recoverable.

❖ **Upper yield point(C) and Lower yield point(D):**

- Beyond elastic limit, the material shows considerable strain even though there is no increase in load or stress.
- **Deformation is not fully recoverable i.e. the behaviour of material is inelastic.**
- This phenomenon from C to D is called yielding.

❖ **Ultimate stress point(E):**

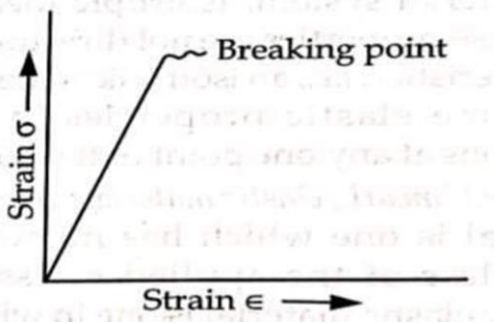
- After yielding has taken place, the material becomes hardened and increase in load is required to take the material to its maximum stress at point E.
- Point E represents the maximum stress of this curve and this point is known as ultimate stress point.

❖ **Breaking point(F):**

- In the portion **EF**, there is falling off the load(stress) from the maximum until fracture takes place at **F**.
- The point **F** is known as fracture or breaking point and corresponding stress is called the breaking stress.

**Q.22 Draw stress-strain diagram for brittle material.**

**Ans:** For brittle materials, like cast Iron, no appreciable deformation is obtained and the failure occurs without yielding.



**Q.23 Define Factor of Safety. (V.Imp.)**

**Ans:** FoS is defined as Ultimate stress to working stress.

$$FOS = \frac{Ultimate\ \ stress}{Working\ \ stress}$$

For safe design FoS must be greater than unity**.**

**Q.24 What is the importance of FoS?**

**Ans:**

1. A factor of safety increases the safety of people and reduces the risk of failure of a product.
2. If a structure fails there is a risk of injury and death as well as a company's financial loss.
3. How much FoS is required depends on the materials andits applications.
4. As the FoS increases, the cost of the product also increases therefore cost is also a considerable parameter.

**Q.25 What are the types of Supports in beam.**

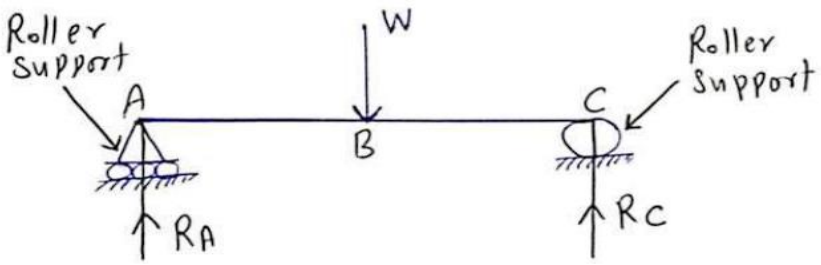
**Ans:**

1. Roller support
2. Hinge(Pin) Support
3. Fixed (Built-in) Support

## Roller support:-

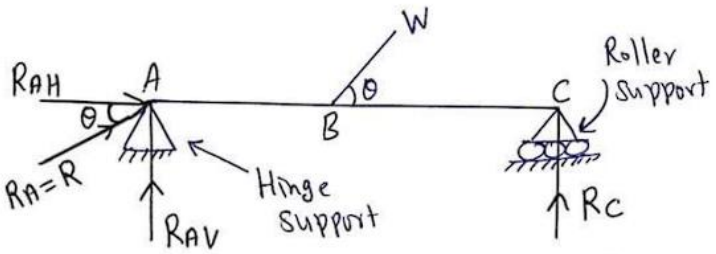
- Axial motion is permitted
- Rotation is permitted
- Only vertical motion is restricted

No of reaction = 1, $R_V$



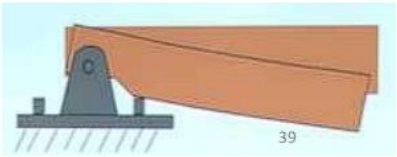
# Hinge support

- Vertical motion is restricted
- Axial motion is restricted
- Rotation is permitted




$$R_A = R = \sqrt{R_{AV}^2 + R_{AH}^2}$$

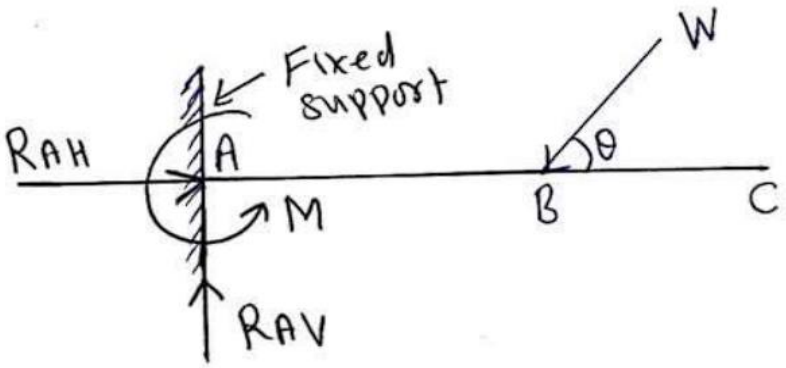
$$\tan\theta = \frac{R_{AV}}{R_{AH}}$$



No of reaction = 2, $R_{AV}$ and $R_{AH}$

# Fixed support/Built-in Support

- Vertical motion is restricted
- Axial motion is restricted
- Rotation is restricted




No of reaction = 3,
$R_{AV}$, $R_{AH}$ and $M_A$

**Q .26 What do you mean by Statically Determinate beam. (V.Imp.)**

**Ans:** Statically Determinate beam:-

If no. of reactions ≤ no. of useful static equations [ƩFx=0, ƩFy=0, ƩM=0]

Ex. i) Simple Supported Beam

ii) Cantilever Beam

iii) Overhanging Beam

# Types of Beams

**2) Statically In-determinate beam:-**

**If no. of reactions > no. of useful static equations [ΣFx=0, ΣFy=0, ΣM=0]**

Ex. i) Fixed Beam
ii) Propped Cantilever Beam
iii) Continuous Beam

**Q .27 What are various types of Beams. (V.Imp.)**

**Ans:**

I. Cantilever Beam

II. Propped Cantilever Beam

III. Fixed Beam

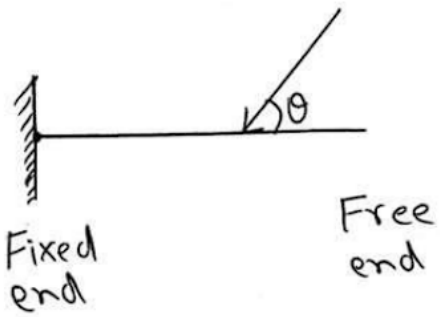
IV. Simple Supported Beam

V. Overhanging Beam

VI. Continuous Beam

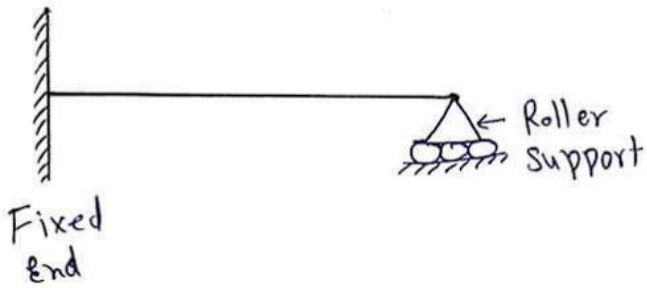
# Cantilever Beam

A beam having its one is fixed or built-in and other end is free to deflect. There no deflection or rotation at its fixed end.



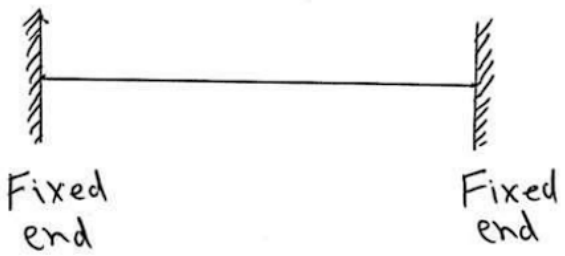
# Propped Cantilever Beam

It is the modification of cantilever beam to reduce the deflection at its free end.




# Fixed Beam

A beam having both the ends fixed or built-in.

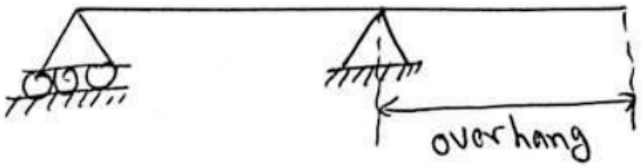



# Simple Supported Beam

A beam having two supports either roller or hinge at both the ends of beam.

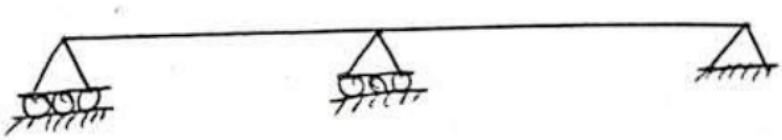
# Over Hanging Beam

A beam having one or both the ends extended over the supports.




# Continuous Beam

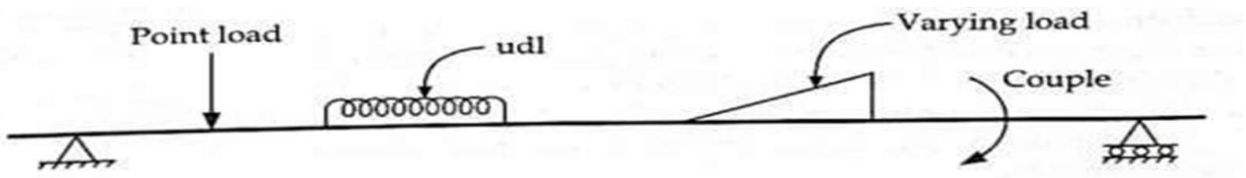
A beam having at least three simple supports not only at ends but at the intermediate location in order to reduce deflection.



## Q.28 Explain types of loads acting on the beam. (V.Imp.)

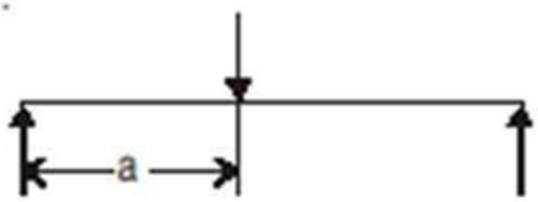
**Ans:**

1. Concentrated load(point load)
2. Uniformly Distributed load(udl)
3. Uniformly Varying load(uvl)
4. Moment

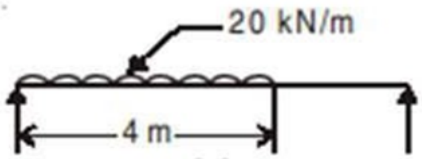


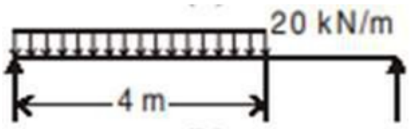
## Concentrated Loads:

- This load acts at a point.
- It is represented by an arrow as shown in Fig.



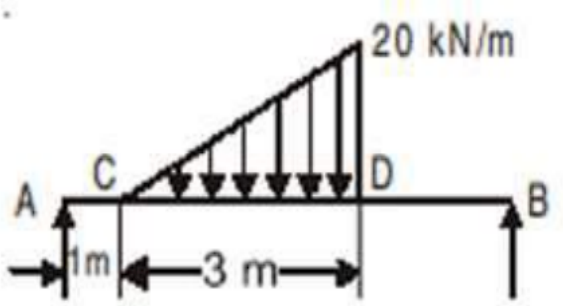

## Uniformly Distributed Load (UDL):




- Load acts over a certain length
- Intensity of load is uniform
- It is represented as shown in Fig
- Total load = Area of plane fig (rectangle)
- Total load acting at middle of the loaded length
- **Given load may be replaced by a $20 \times 4 = 80$ kN, concentrated load acting at a distance 2 m from the left support.**

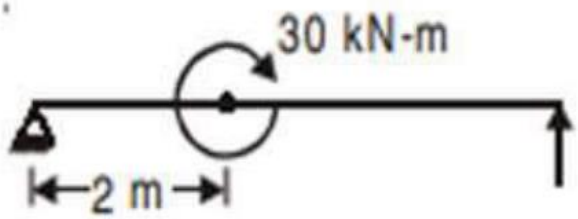
## Uniformly Varying Load(UVL):




- The load varies Uniformly from C to D.
- Its intensity is zero at C and is 20 kN/m (maximum) at D.
- Total load = Area of plane fig (triangle)
- Centroid of the triangle represents the center of gravity of the load. ($1/3^{rd}$ from **D** or $2/3^{rd}$ from **C**)
- Total load is $1/2 \times 3 \times 20 =$ **30 kN**
- This load is equivalent to 30 kN acting at 3 m from A.

## External Moment:

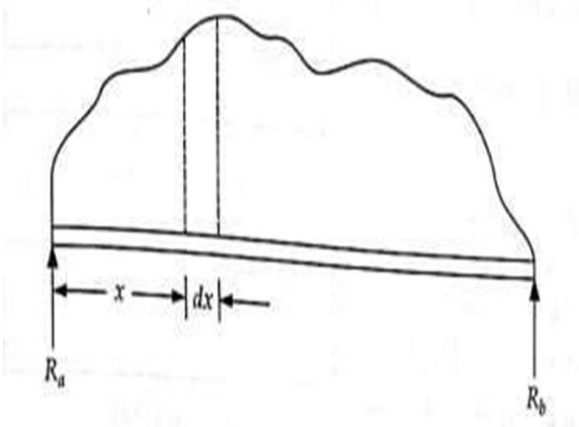
- A beam may be subjected to external moment at certain points.
- In Fig. the beam is subjected to clockwise moment of 30 kN-m at a distance of 2 m from the left support.

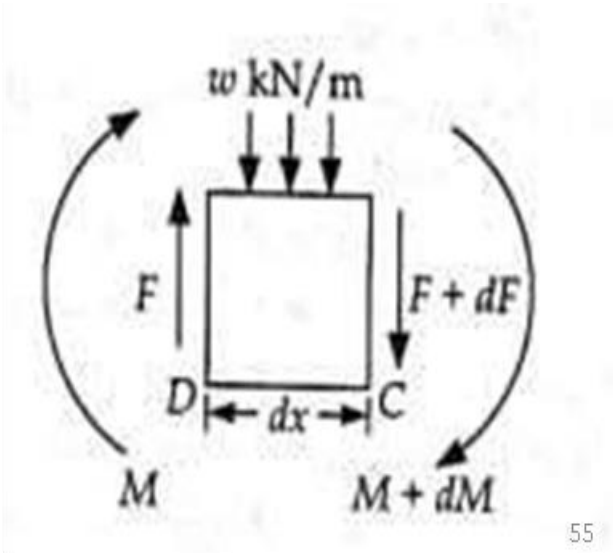



## Q.29 Relationship between Load Intensity, Shear Force and Bending Moment.

Ans:

1. Consider the beam AB subject to a general loading as shown in Fig.
2. The free body diagram of a segment of beam at a distance x from A and of length dx is shown in Fig.
3. The intensity of loading on this elemental length may be taken as constant.
4. Let the intensity is w/unit length.
5. Let F is shear force and M is bending moment acting on the section at a distance x from A.
6. At section at a distance x + dx, these values are F + dF and M + dM respectively.

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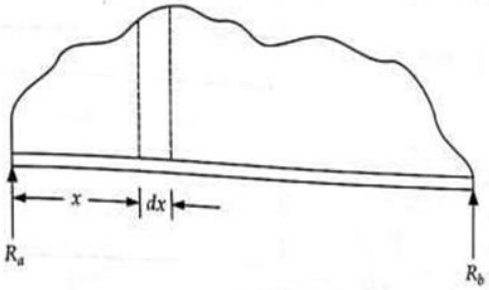
Now from the equilibrium of the element.




Taking moments about point C on the right side,

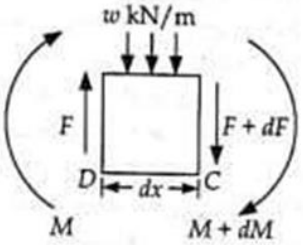
$$\Sigma M_c = 0: \qquad M - (M + dM) + F \times dx - (w \times dx) \times \frac{dx}{2} = 0$$

The udl is considered to be acting at its CG

$$dM = F\,dx - \frac{w\,(dx)^2}{2} = 0$$

The last term consists of the product of two differentials and can be neglected.

$$\therefore \qquad dM = F\,dx \text{ or } F = \frac{dM}{dx}$$




Thus the shear force is equal to the rate of change of bending moment with respect to $x$.

Applying the condition $\Sigma F_y = 0$ for equilibrium, we obtain

$$F - w\,dx - (F + dF) = 0$$

or $$w = \frac{dF}{dx}$$

That is the intensity of loading is equal to rate of change of shear force with respect to $x$.

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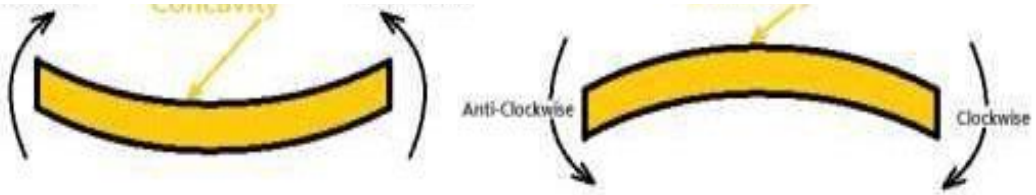
## Q .30 What is Sagging and hogging bending moment?

## Ans:




Postitive Bending Moment

Sagging Moment

(a)

Negitive Bending Moment

Hogging Moment

(b)

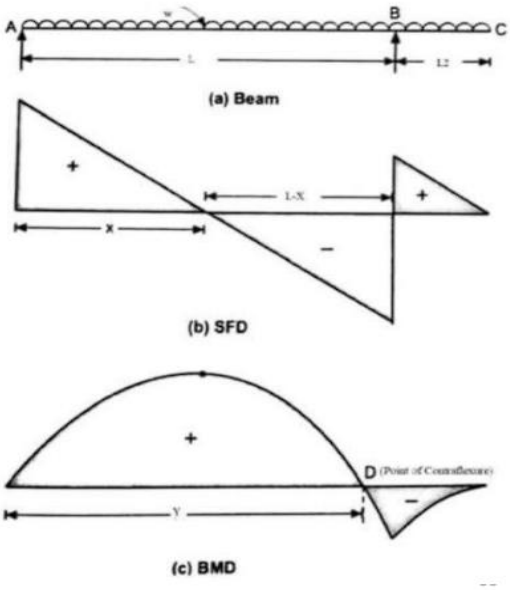
- **Sagging Bending Moment:** The bending moment which causes a beam to bend with the **concave side upwards** is called a **Sagging Bending Moment.**
- **Hogging Bending Moment:** The bending moment that cause a beam to bend with the **convex side upward** is called **Hogging Bending moment**

## Q .31 What is point of contra-flexure in beam?

**Ans:**

A **point of contra-flexure** is a **point** where bending is zero(BMD changes its sign).

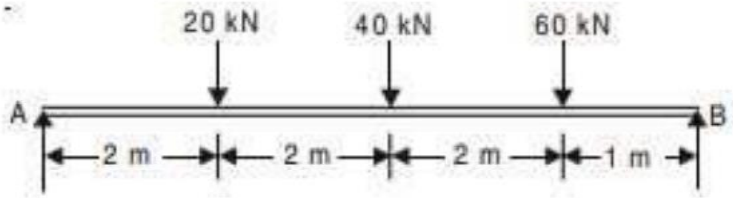
- It is sometimes referred to as a **point** of inflexion.
- Point "D" is point of contra-flexure as shown in fig..




## Q.32 What is the Concept of Shear Force and bending moment ?

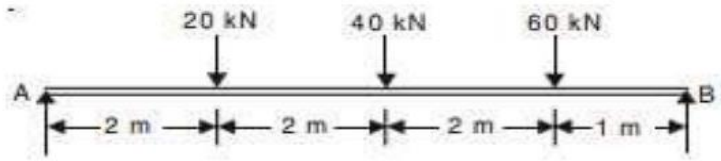
**Ans:**

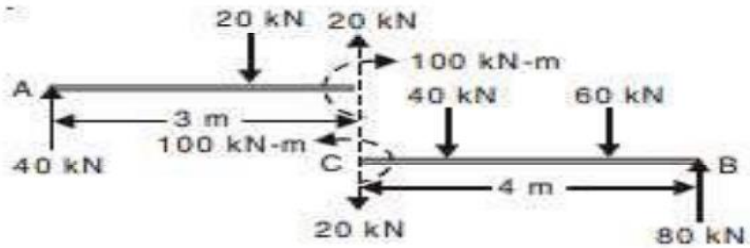
$$\sum M_B = 0, \text{ gives}$$
$$R_A \times 7 = 20 \times 5 + 40 \times 3 + 60 \times 1$$
$$R_A = 40 \text{ kN}$$
$$R_B = (20 + 40 + 60) - 40$$
$$= 80 \text{ kN}$$




**Shear Force:**

It is defined as the algebraic sum of vertical forces(including reactions) acting either on LHS of the section or RHS of the section.




consider the section at C at a distance of 3 m from A

LHS of the section
$F_{Left} = 40 - 20 = 20$ Upward

RHS of the section
$F_{Right} = 80 - 60 - 40 = -20$ Downward

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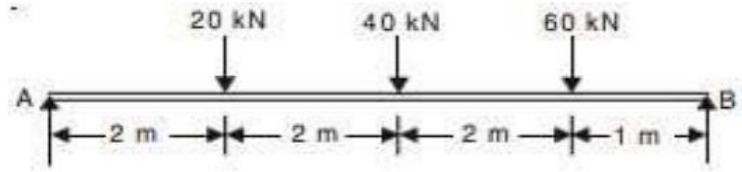
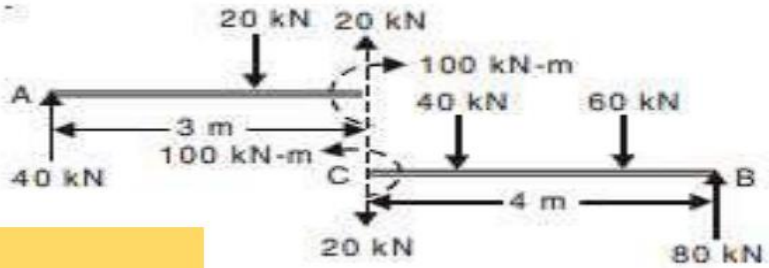
## Bending Moment:

It is defined as the algebraic sum of moments acting either on LHS of the section or RHS of the section.




LHS of the section

$M_{Left}$ = 40x3 – 20X1 = 100kN-m Clockwise

RHS of the section

$M_{Right}$ = 80x4 – 60x3 – 40x1 = 100 Anti-Clockwise

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# BUDDHA SERIES

## (Unit Wise Solved Question & Answers)

## Course – B.Tech

## College – Buddha Institute of Technology

**(AKTU CODE-525)**

## Department: ASH 1

## Subject: Fundamental of Mechanical Engineering (BME101)

## Faculty Name: Mohd Faizan / S .B lal

## Unit - 2

# Syllabus (UNIT 2)

IC Engine: Basic Components, Construction and Working of Two stroke and four stroke SI & CI engine, merits and demerits, scavenging process; Introduction to electric, and hybrid electric vehicles.

**Q.1: Define an engine.**

**Ans:** It is a device which converts one form of energy into another form of useful energy.

Based on combustion engines are classified into:

1. Internal Combustion Engine (I.C. Engine)

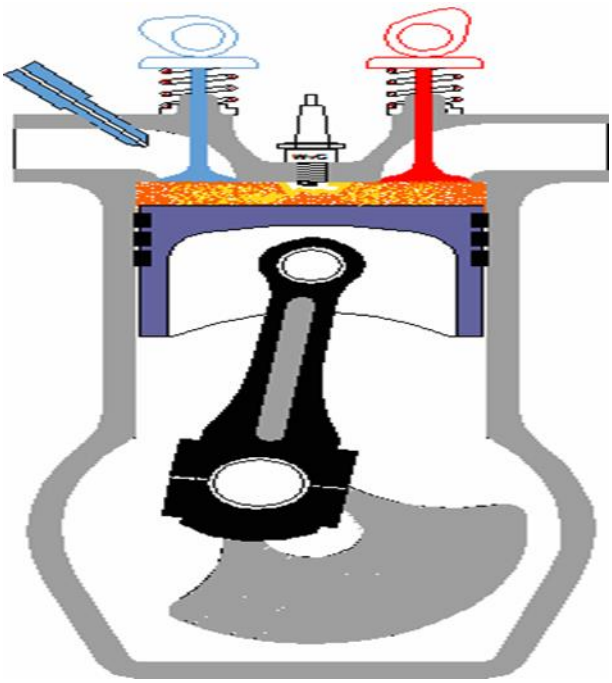
2. External Combustion Engine (E.C. Engine)

**Q.2 Define an Internal Combustion Engine.**

**Ans:** In internal combustion engine the burning or combustion of the fuel takes place inside the cylinder.

Example- Automobile engines

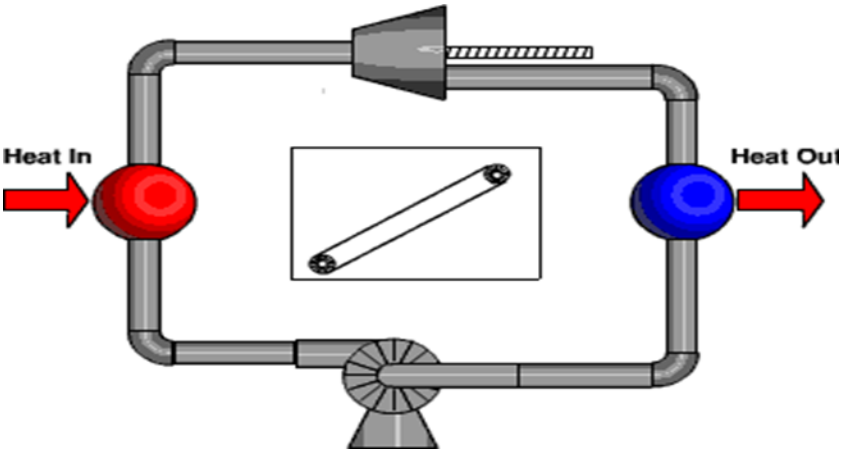
1. Petrol engine
2. Diesel engine



**Q .3 What is External Combustion Engine?**

**Ans**: In external combustion engine the combustion of the fuel takes place outside the engine.

Example- Steam engine, Closed gas turbine etc.




**Q .4 What is the difference between ICE and ECE?**

**Ans:**

| S. No. | EC Engine | IC Engine |
|---|---|---|
| 1 | Combustion of fuel is outside the engine | Combustion of fuel is inside the engine |
| 2 | Bulky due to presence of auxiliary apparatus like boiler and condenser. | It is light and compact |
| 3 | High ratio of weight to power output | Low ratio of weight to power output |
| 4 | It can use cheaper fuels including solid fuels | High grade fuels are used with proper filtration |
| 5 | Higher requirement of water for dissipation of heat | Lesser requirement of water |
| 6 | Lower efficiency about 15-20% | Higher efficiency about 35-40% |
| 7 | Silent operation due to outside combustion | Very noisy operated engine |

**Q.5 What are Advantages of I.C. Engine?**

**Ans: These are the following advantages of an I.C. Engine**

1. Mechanical Simplicity
2. Low initial cost due to absence of boiler, turbinecondenser etc.
3. High efficiency than external combustion engine
4. Power to weight ratio is high
5. Very suitable for small power requirement applications
6. Starting time is very less
7. Requires less maintenance

**Q. 6 What are the Disadvantages of I.C. Engine?**

**Ans**: These are the following disadvantages of an I.C. Engine:

1. Variety of fuels that can be used is limited to very fine quality gaseous and liquid fuel.
2. Fuel used is very costly like gasoline or diesel.
3. Engine emissions are generally high compared to external combustion engine.
4. Not suitable of large scale power generation.
5. In case of reciprocating internal combustion noise is generated due to detonation.

**Q.7 Give the Classification of I.C. Engine.**

**Ans: On the basis of strokes used:**

1. Two Stroke cycle Engines
2. Four Stroke Cycle Engines
3. On the basis of cycle used
4. Otto Cycle Engines
5. Diesel Cycle Engines
6. Dual Cycle Engines

**On the basis of types of fuel used:**

1. Petrol Engines
2. Diesel Engines
3. Gas Engines

**On the basis types of Ignition Method :**

1. Spark Ignition (SI)
2. Compression Ignition (CI)

**On the basis types of cooling system used:**

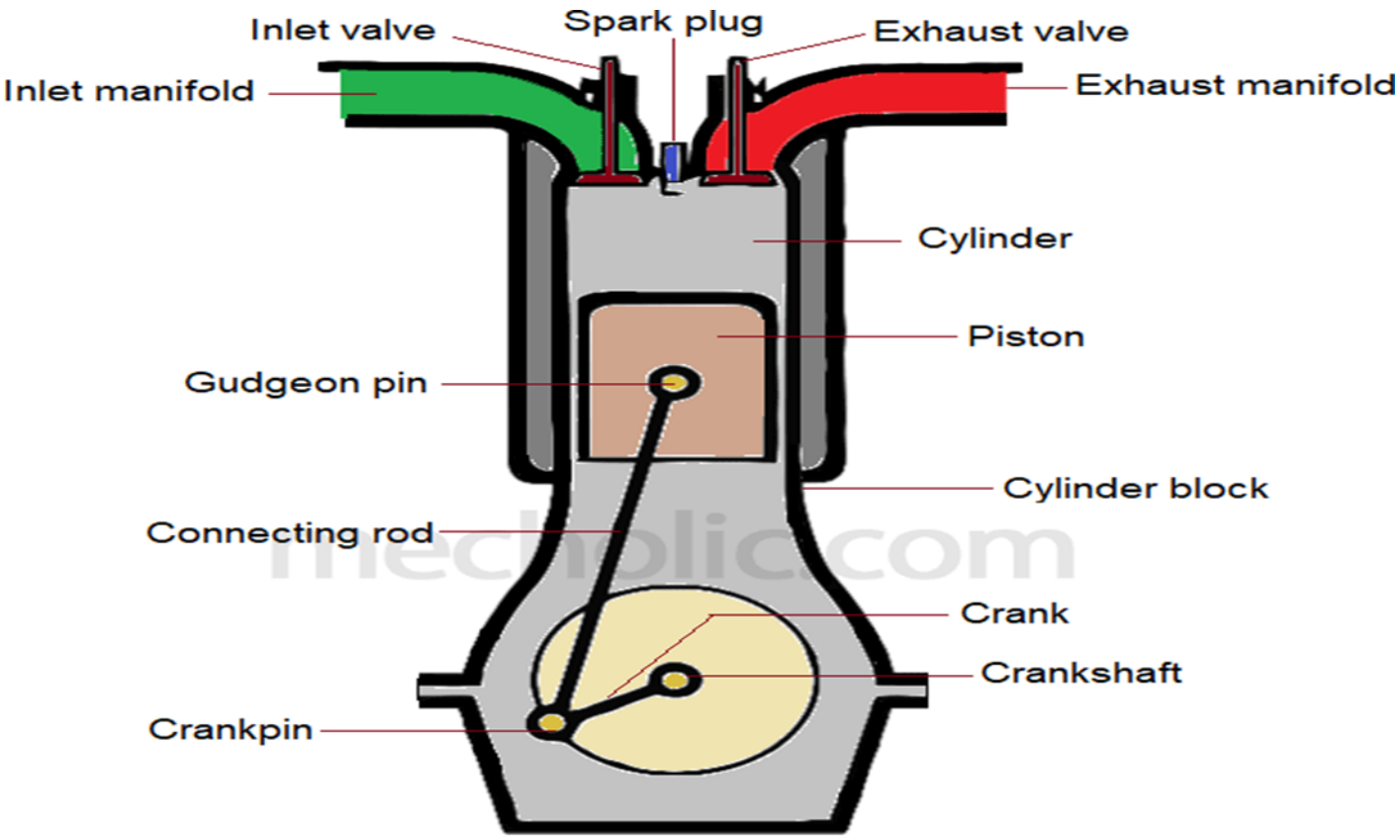
1. Air cooled engines
2. Water cooled engines

**On the basis types of different position of cylinder engines:**

1. Horizontal cylinder engines
2. Vertical cylinder engines

**Q .8 What are the main Components of I.C.E.?**

**Ans:**



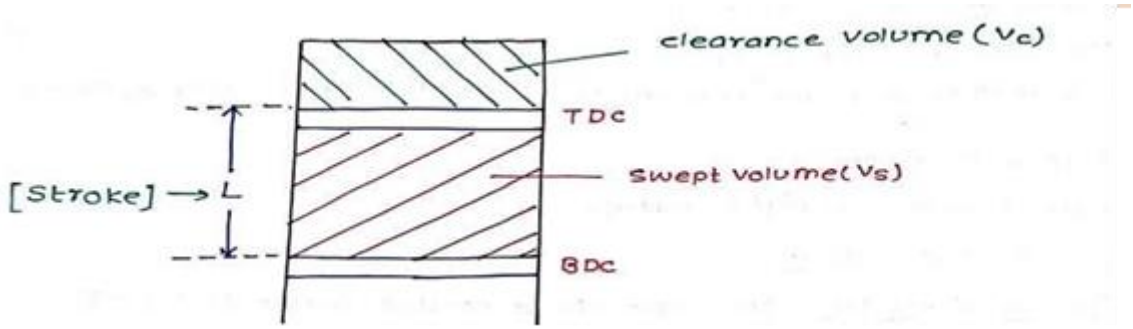
**Q.9 Define TDC and BDC in an I.C.E.**

**Ans:** Top-Dead-Center (TDC): It is position of the piston when it is farthest from the crank shaft.

**Note:-**In case of horizontal engine TDC is known as inner dead center (IDC)

Bottom-Dead-Center (BDC): It is the position of the piston when it is nearest to the crankshaft.

**Note:-**In case of horizontal engine BDC is known as outer dead center(ODC).




**Q .11 Define Bore, Swept volume and clearance Volume.**

**Ans: Bore (D):** Inner diameter of the cylinder or diameter of the piston face.

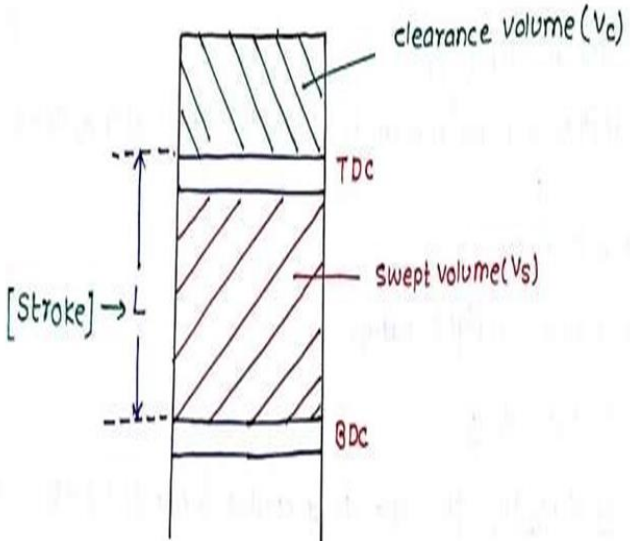
**Swept Volume (VS):** Volume displaced by the piston as it travels through one stroke.

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

If there are K no. of cylinders then total swept Volume

$$V_S = K \frac{\pi}{4} D^2 L$$

**Clearance Volume (VC):** It is the volume of the cylinder when piston is at TDC or IDC, therefore it is minimum volume.



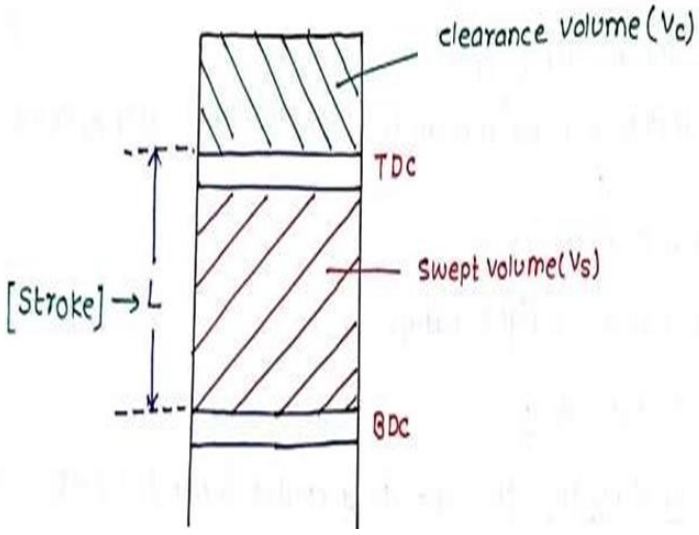

**Q .12 Define Compression ratio in an ICE.**

**Ans: Compression ratio (r):** It is defined as the ratio of volume before compression to the volume of after compression.

Volume before compression = $V_c + V_s$

Volume after compression = $V_C$

$$\mathbf{r = \frac{V_C + V_S}{V_C}}$$



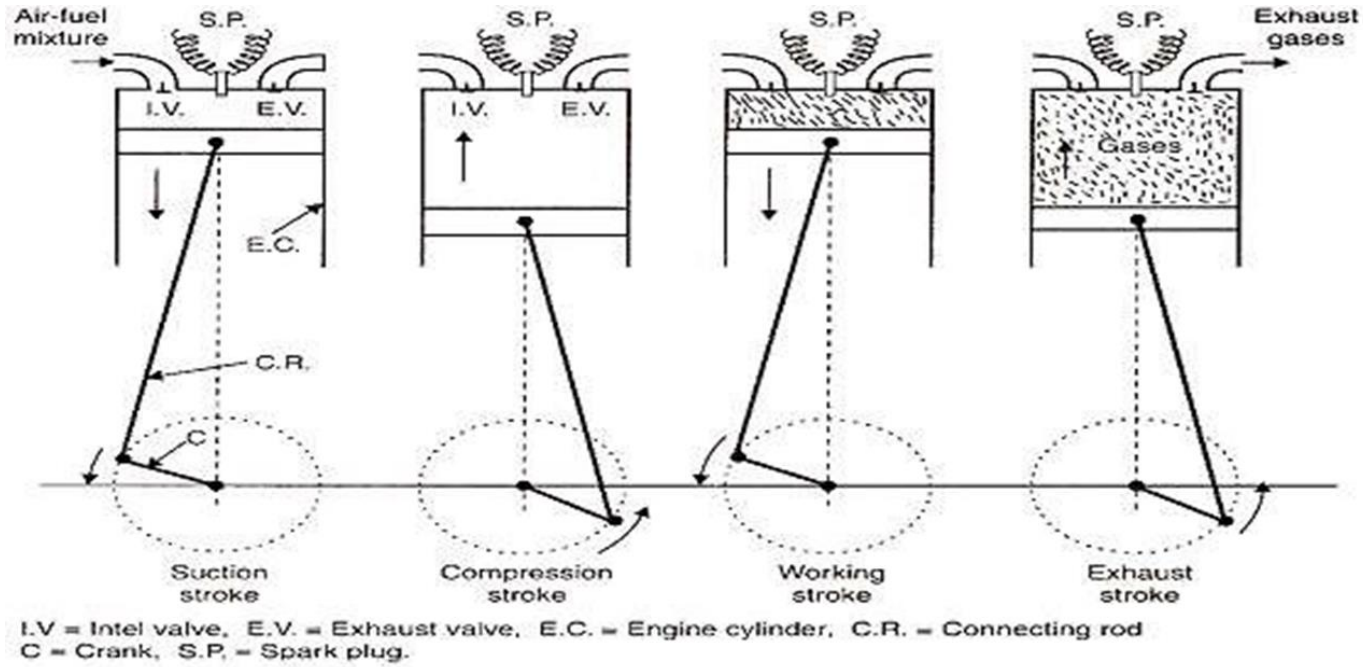

**Q.13 What do you mean by Four Stroke Engines?**

**Ans:** Cycle operations (Intake, Compression, Expansion or power and Exhaust) completed in four strokes of the piston or two revolution (720º) of the crank.

**Four Stroke Engines may SI or CI.**

**Q.14 Explain with suitable sketches the working of Four Stroke SI Engines.**

**Ans:**




I.V = Intel valve, E.V. = Exhaust valve, E.C. = Engine cylinder, C.R. = Connecting rod
C = Crank, S.P. = Spark plug.

**Working:**

**Suction Stroke:**

1. Piston moves down from TDC to BDC.
2. Inlet valve is opened and the exhaust valve is closed.
3. Pressure inside the cylinder is reduced below the atmospheric pressure.
4. The mixture of air fuel is sucked into the cylinder through the inlet valve.

**Compression Stroke:**

1. Piston moves up from BDC to TDC.
2. Both inlet and exhaust valves are closed.

3. Temperature and pressure increased due to compression of air fuel mixture in the cylinder.

**Power or Expansion Stroke:**

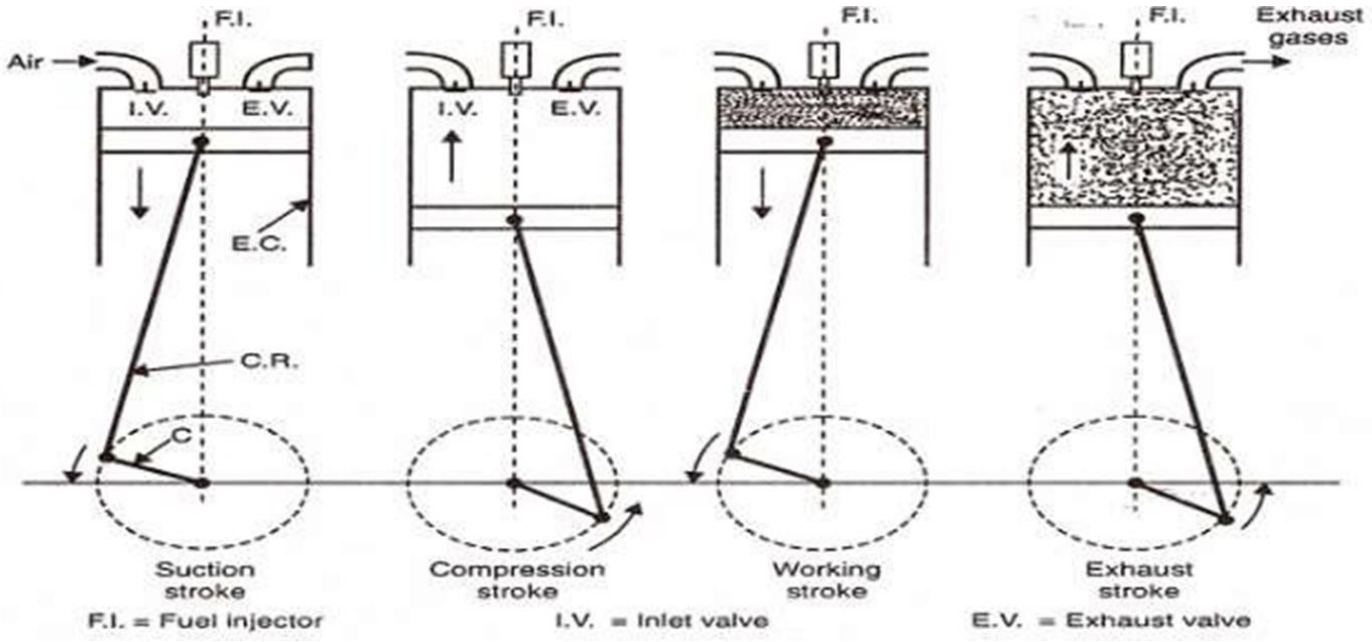
1. The burning gases expand rapidly.
2. Gases exert an impulse (thrust or force) on the piston.
3. The piston is pushed from TDC to BDC.
4. This reciprocating motion of the piston is converted into rotary motion of the crankshaft through connecting rod.
5. Both inlet and exhaust valves are closed.

**Exhaust Stroke:**

1. Piston moves upward from BDC to TDC.
2. Exhaust valve is opened and the inlet valve is closed.
3. The burnt gases are forced out to the atmosphere through the exhaust valve.
4. The inlet valve opens slightly before TDC and the cylinder is ready to receive fresh charge to start a new cycle.

**Q.15 Explain with suitable sketches the working of Four Stroke CI Engines.**

**Ans:**



**Working:**

**Suction Stroke:**

1. Piston moves from TDC to BDC.
2. Inlet valve is opened and the exhaust valve is closed.
3. The pressure inside the cylinder is reduced below the atmospheric pressure.
4. Fresh air from the atmosphere is sucked into the engine cylinder through air cleaner and inlet valve.

**Compression stroke:**

1. Piston moves from BDC to TDC.
2. Both inlet and exhaust valves are closed.
3. The only air is drawn during suction stroke is compressed to a high pressure and temperature.

**Power or expansion stroke:**

1. Fuel (diesel) is injected inside the cylinder with the help of fuel injector.
2. The burning gases expand rapidly and push the piston from TDC to BDC.
3. This movement of piston is converted into rotary motion of the crank shaft through connecting rod.
4. Both inlet and exhaust valves are closed. Exhaust Stroke:
5. Piston moves from BDC to TDC.
6. Exhaust valve is opened the inlet valve is closed.
7. The burnt gases are forced out to the atmosphere through the exhaust valve.
8. The inlet valve opens slightly before TDC and the cylinder is ready to receive fresh air to start a new cycle.

**Q.16 Write down the differences between SI and CI Engines.**

**Ans:**

| S. No. | SI Engine | CI Engine |
|---|---|---|
| 1 | It works on OTTO Cycle or constant volume heat addition. | It works on DIESEL Cycle or constant pressure heat addition. |
| 2 | During the intake or suction process, air and fuel are used. | During the intake or suction process, only air is used. |
| 3 | The fuel used Petrol which is highly volatile. Self Ignition temperature is high. | The fuel used Diesel which is low volatile. Self-ignition temperature is low. |
| 4 | The fuel is supplied by Carburetor. | The fuel is supplied by Injector. |
| 5 | The maintenance cost is low. | The maintenance cost is high. |
| 6 | It is used in Small Vehicles. | It is used in Heavy Vehicles. |
| 7 | The compression ratio is 6 to 10. | The compression ratio is 16 to 22. |
| 8 | The starting of this engine is easy. | Starting is a little difficult comparatively SI engine. |
| 9 | It produces less noise. | It produces high noise. |
| 10 | Lower thermal efficiency because of the low compression ratio. | High thermal efficiency because of the high compression ratio. |

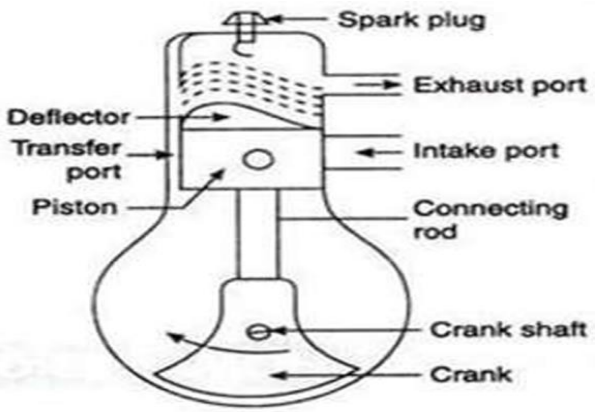
**Q.17 What do you mean by Two Stroke Engines?**

**Ans:** Cycle operations (Intake, Compression, Expansion or power and Exhaust) completed in two strokes of the piston or one revolution (360º) of the crank.

Two Stroke Engines may SI or CI.

**Q.18 Explain with suitable sketches the working of Two Stroke SI Engines.**

**Ans:**




**Working:**

**Compression and Ignition:**

1. The piston moves from (BDC) to (TDC).
2. Both transfer and exhaust ports are covered by the piston.
3. Air fuel mixture is compressed by moving piston. The pressure and temperature increases at the end of compression.
4. As piston almost reaches the top dead center. The air fuel mixture inside the cylinder is ignited by means of an electric spark produced by a spark plug.
5. At the same time, the inlet port is uncovered by the piston. Fresh air fuel mixture enters the crankcase through the inlet port.

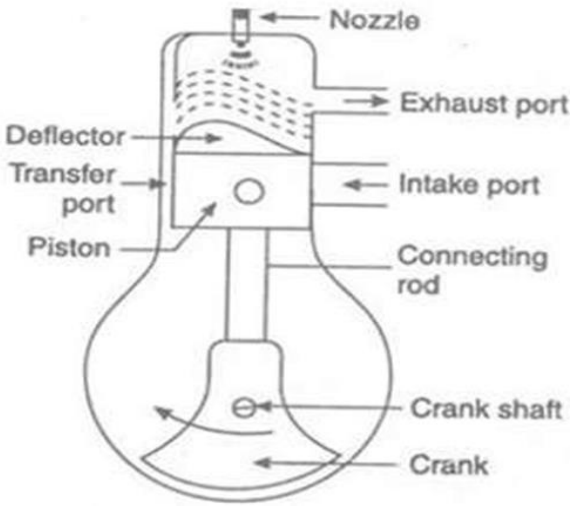
**Expansion and Exhaust:**

1. The burning gases expand in the cylinder. The burning gases force the piston to move down. Thus useful work is obtained.
2. When the piston moves down, the air fuel mixture in the crankcase is partially compressed.
3. This compression is known as crank case compression.

4. At the end of expansion, exhaust port is uncovered. Burnt gases escape to the atmosphere. Transfer port is also opened.

**Q.19 Explain with suitable sketches the working of Two Stroke CI Engines.**

**Ans:**




**Working:**

**Compression and ignition:**

1. The piston moves upwards from (BDC) to (TDC). Both transfer and exhaust ports are covered.
2. Air which is transferred already into the engine cylinder is compressed by moving piston.
3. The pressure and temperature of the air increases.
4. Piston almost reaches the top dead center. The fuel is injected into the hot compressed air inside the cylinder.
5. The fuel mixed with hot air and burns.
6. The admission of fresh air into the crankcase continues till the piston reaches the top dead center.

**Expansion and Exhaust:**

1. The burning gases expand in the cylinder.
2. Burning gases force the piston to move down. Thus useful work is obtained.
3. At the same time, the air in the crank case is compressed by the movement of the piston from BDC to TDC.
4. At the end of expansion, the exhaust port is uncovered.
5. The burnt gases escape to the atmosphere through the exhaust port.

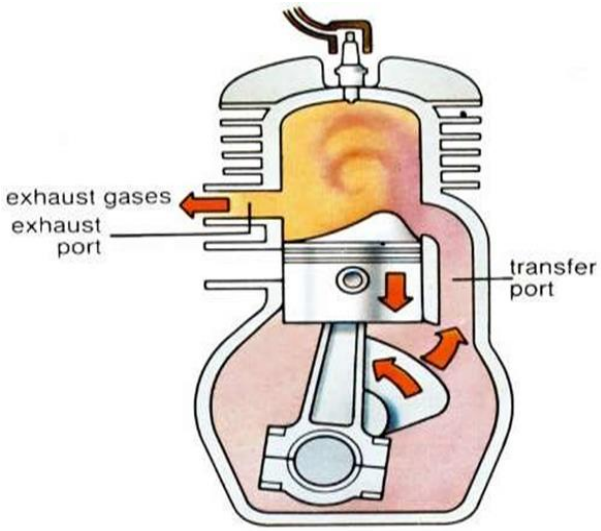
**Q.20 Write down the differences between 4 strokes and 2 strokes engine.**

**Ans:**

| S. No. | 4-stroke | 2-Stroke |
|---|---|---|
| 1 | Four stroke of the piston and two revolution of crankshaft | Two stroke of the piston and one revolution of crankshaft |
| 2 | One power stroke in every two revolution of crankshaft | One power stroke in each revolution of crankshaft |
| 3 | Power produce is less | Theoretically twice power |
| 4 | Heavier flywheel due to non-uniform turning movement | Lighter flywheel due to more uniform turning movement |
| 5 | Lesser cooling and lubrication requirements | Greater cooling and lubrication requirements |
| 6 | Contains valve and valve mechanism | Contains ports arrangement |
| 7 | Volumetric efficiency and Thermal efficiency is high | Volumetric efficiency and Thermal efficiency is low |
| 8 | Heavy and bulky | Light and compact |

**Q.21 What is Scavenging process?**

**Ans:**



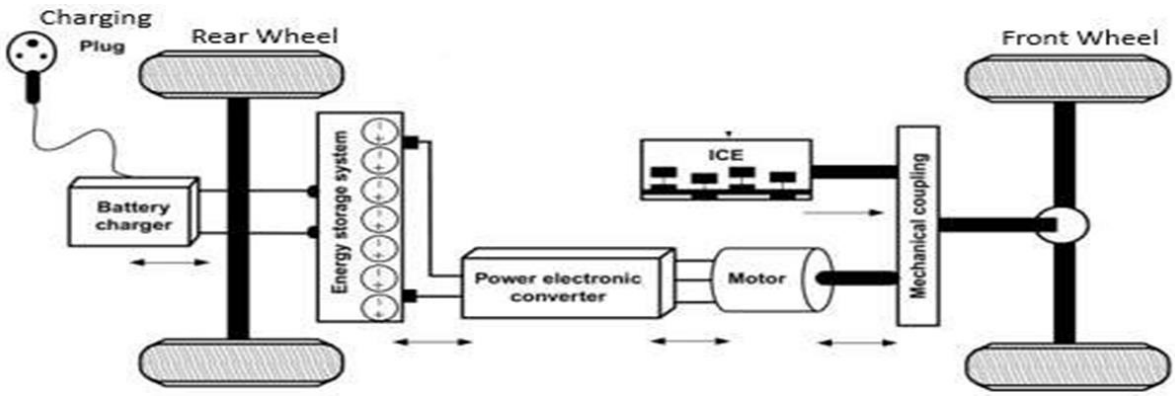

1. Scavenging is a process of pushing exhaust gases out of the cylinder.
2. This action takes place in the two stroke engine.
3. The charge (air fuel mixture or air) enters the engine cylinder from the crank case at a pressure higher than the exhaust gases.
4. This fresh charge forces the burnt gases to the atmosphere through the exhaust port. During the period both the transfer and exhaust ports are kept open for a short period.
5. Hence there is a possibility of the fresh charge escaping out with the burnt gases.
6. This is over- come by designing the piston to have a deflected shape.
7. This shape of piston deflects the fresh charge upward in the engine cylinder. It also helps out in forcing out the burnt gases to atmosphere.

**Q.22 What is electric vehicle? What are the main components of electric vehicle?**

**Ans:** ► An electric vehicle (EV) is a vehicle that uses one or more electric motor for propulsion.

► The electric motors are the replacement of ICE.

► Main components of electric vehicle are Battery, Electric motor, Battery charger, Power electric converter.




## Electric Vehicles

❖ *Advantages:*

- ➢ Better for the environment.
- ➢ Electricity is less expensive than fuels.
- ➢ Less maintenance at a lower cost.
- ➢ Produce less noise.

❖ *Disadvantages:*

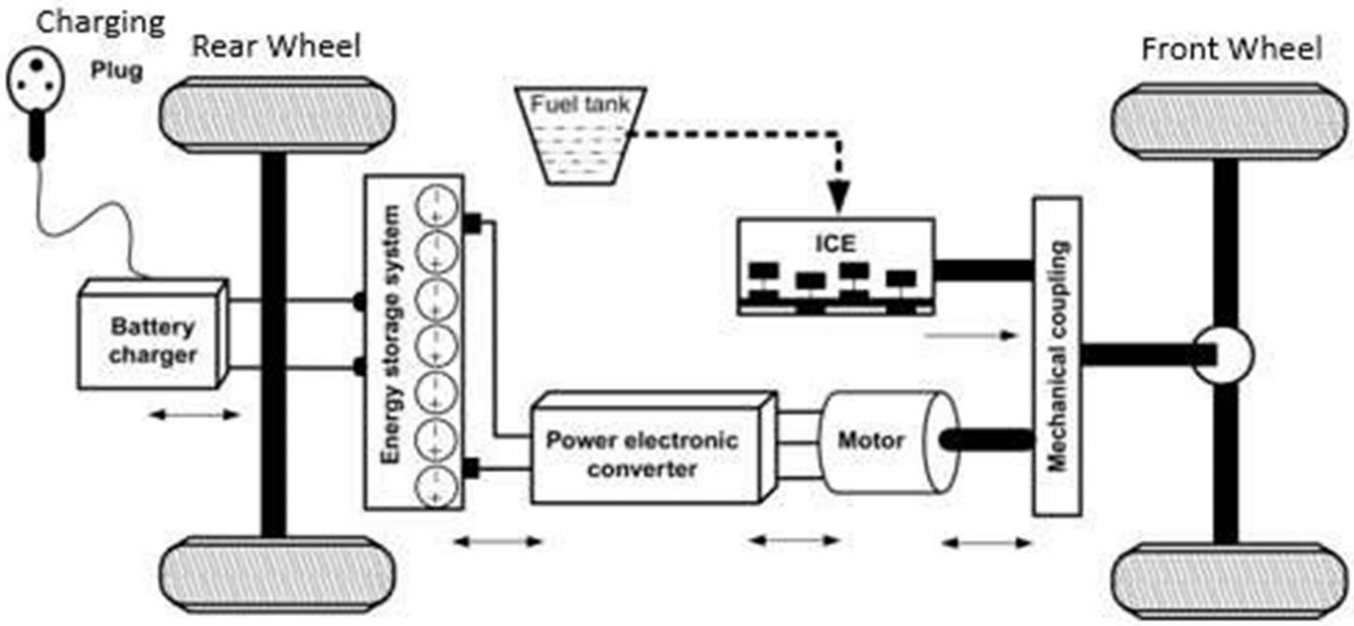
- ➢ EVs have short ranges for driving.**(100 to 400 km)**
- ➢ Charging can take a lot of time.
- ➢ Initial investment is high.
- ➢ Charging stations are not available everywhere.

**Q.23 What is hybrid vehicle? Give the classification of hybrid vehicles?**

**Ans:** ► Hybrid electric vehicle (HEV) is a type of hybrid vehicle that combines a conventional internal combustion engine (ICE) system with an electric propulsion system .

► Modern HEVs make use of efficiency-improving technologies such as regenerative brakes which convert the vehicle's kinetic energy to electric energy, which isstored in a battery or super-capacitor.

# Hybrid Electric Vehicles




## Types of Hybrid Vehicles

### Parallel Hybrid

Toyota Camry, Honda Accord, Toyota Prius, Hyundai Sonata, etc.

### Series Hybrid

BMW i3, Kia Optima, Ford Fusion, Chevrolet Volt, etc.

### Plug-in Hybrid

BMW 330e, Hyundai Ioniq Plug-in Hybrid, Volvo XC40

### Mild-Hybrid

Maruti Suzuki Ertiga, Ciaz, Baleno, etc.

## Advantages of Hybrid Cars

1. **Cleaner Emission:** Compared to the **ICE** engine, hybrid cars produce less emissions and it is environmental friendly.
2. **Less Fuel Dependency:** With an electric motor to support the primary petrol engine, there is additional power available. Hence, there is less dependency on fossil fuel.
3. **Smaller and Efficient Engine:** Petrol engines used in hybrid cars are smaller in size and comparatively fuel efficient.

# Disadvantages of Hybrid Cars

- **Lower Performance:** Since the main motive is to increase the fuel efficiency or range of the hybrid car, the power oracceleration can lag behind a conventional internal combustion engine car.
- **Expensive to Buy:** Although car companies are trying to bridge the gap in pricing between a conventional vehicle and hybrid, hybrids continue to demand higher costs.
- **High Maintenance Cost:** With several mechanical parts in the cars and with two sets of engines powering the hybrids, the maintenance continues to be on the higher side. Also, not all mechanics are trained to repair a hybrid car.
-

**Q.24 Compare the relative advantages and disadvantages among IC engine, Electric and Hybrid vehicles.**

**Ans:**

| | Electric Vehicles | Hybrid Electric Vehicles | I.C.Engines |
|---|---|---|---|
| **Power/Fuel Source** | Electricity Through Battery Pack (DC) | Electricity and Fossil Fuel (Petrol and Diesel etc) | Fossil Fuel (Petrol and Diesel etc) |
| **Engine** | Electric Motor(s) | Internal Combustion Engine and Electric Motor(s) | Internal Combustion Engine |
| **Fuel Efficiency** | Depends on Battery Range | Combination of ICE and Battery Range | Internal Combustion Engine |
| **Emission Levels** | Lower Compared to ICE and Hybrid vehicles | Higher Compared to Electric vehicles | High |
| **Price Range** | High | Similar to Conventional ICE vehicles | Low as compared to EVs |
| **Charging** | Required | Not required | Not required |

# BUDDHA SERIES

## (Unit Wise Solved Question & Answers)

## Course – B.Tech

## College – Buddha Institute of Technology

**(AKTU CODE-525)**

## Department: ASH 1

## Subject: Fundamental of Mechanical Engineering (BME101)

## Faculty Name: Mohd Faizan / S .B lal

## Unit - 3

# Refrigeration

Its meaning and application, unit of refrigeration; Coefficient of performance, methods of refrigeration, construction and working of domestic refrigerator, concept of heat pump. Formula based numerical problems on cooling load.

**Q.1 Define refrigeration and refrigerant. What are the applications of refrigeration in different fields.**

**Ans:** Refrigeration is a process of maintaining lower temperature compare to surrounding temperature.

1. In order to maintain temperature continuously refrigeration system must run on a cycle.
2. Refrigerant is a substance used for producing lower temperature.
3. Example are NH3, water, air, R-11, R-12, R-134 etc.
4. Refrigerants absorb heat at a low temperature and reject heat at a higher temperature.

**Applications of Refrigeration**

1. Domestic refrigeration
2. Chemical refrigeration
3. Industrial refrigeration
4. Transport refrigeration
5. Air-conditioning

**Q.2 Give the name of any four environment friendly refrigerants.**

**Ans**: 1. These include ethane, propane, isobutane, difluoromethane (HFC-32), and a blend of four alkanes called R-441A (ethane, propane, butane, and isobutane).

2. These refrigerants are already being used in some places around the world.

**Q.3 Explain the term 1 tonne of refrigeration. What are the methods of refrigeration?**

**Ans:** 1. It is the amount of heat that is to be removed from one tonne of water at zero (0oC) in order to convert it into ice at 0 oC in one day (24 hours).

2. Tonne of refrigeration represents heat transfer rate. 1 T.R. = 3.5 kJ/s = 3.5 kW = 210 kJ/min

## Methods for Refrigeration

**Natural Refrigeration Methods**

1. Natural ice for refrigeration
2. Evaporative Cooling

**Artificial Refrigeration Methods**

1. Gas refrigeration system
2. Vapour Compression refrigeration system
3. Vapour absorption system

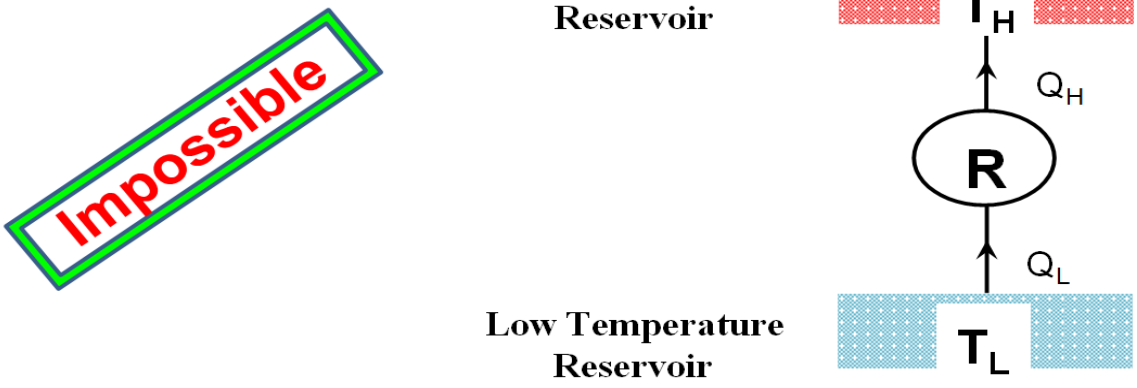
**Artificial Refrigeration Methods**

1. Gas refrigeration system
2. Vapour Compression refrigeration system

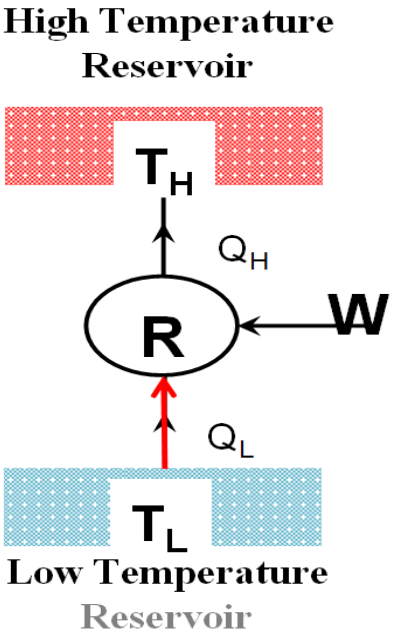
### Q.4 Define refrigerator and heat pump.

### Ans:

**Clausius Statement:** "It is impossible to construct a device which operates on a cycle and transfer heat from low temperature body to high temperature body **without any external work**."

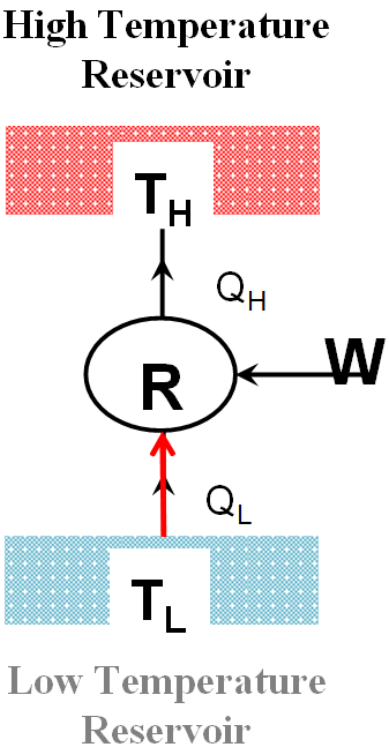


# Refrigerator




- Refrigerator works on the Clausius statement.
- It absorb the heat from the low temperature medium and rejects heat into high temperature medium by consuming external work.
- Refrigerator used to maintain **low temperature** as compared to surrounding.

# Refrigerator



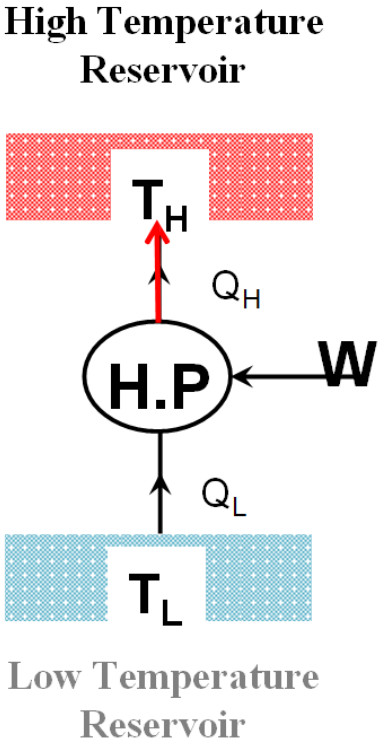

$$COP_R = \frac{Desired\ Effect}{Work\ Required}$$

$$COP_R = \frac{Cooling\ Effect}{Work\ Required}$$

$$COP_R = \frac{Q_L}{W}$$

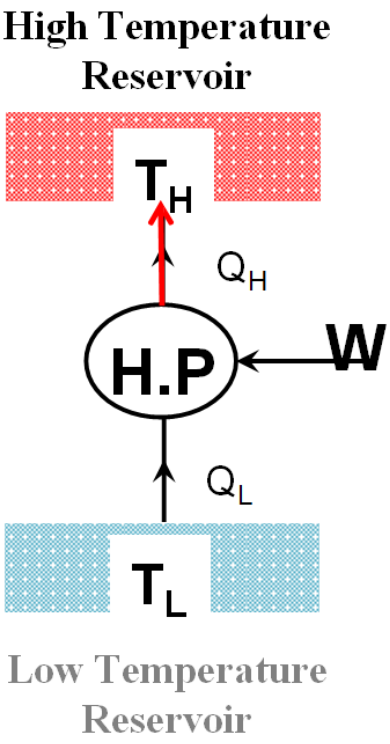
$$COP_R = \frac{Q_L}{Q_H - Q_L}$$

# Heat Pump




- Heat Pump works on the Clausius statement.
- It absorb the heat from the low temperature medium and rejects heat into high temperature medium by consuming external work.
- Heat pump used to maintain **High temperature** as compared to surrounding.

# Heat Pump



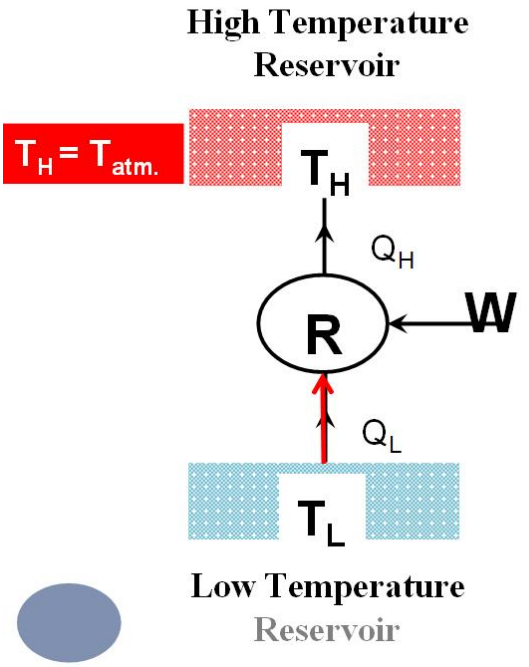

$$COP_{H.P.} = \frac{Desired\ Effect}{Work\ Required}$$

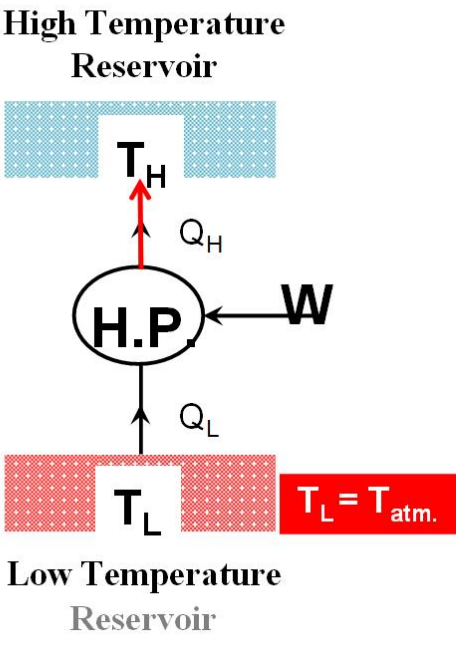
$$COP_{H.P.} = \frac{Heating\ Effect}{Work\ Required}$$

$$COP_{H.P.} = \frac{Q_H}{W}$$

$$COP_{H.P.} = \frac{Q_H}{Q_H - Q_L}$$

# Refrigerator & Heat Pump




**Q.5 Derive the relation between the COP of refrigerator and heat pump.**

**Ans:**

$$COP_{HP} = \frac{Q_H}{W} \quad \Rightarrow \quad COP_{HP} = \frac{Q_H}{Q_H - Q_L}$$

$$\Rightarrow \quad COP_{HP} = \frac{Q_H}{Q_H - Q_L} - 1 + 1 \quad \Rightarrow \quad COP_{HP} = \frac{Q_H - Q_H + Q_L}{Q_H - Q_L} + 1$$

$$\Rightarrow \quad COP_{HP} = \frac{Q_L}{Q_H - Q_L} + 1$$

$$COP_{HP} = COP_R + 1$$

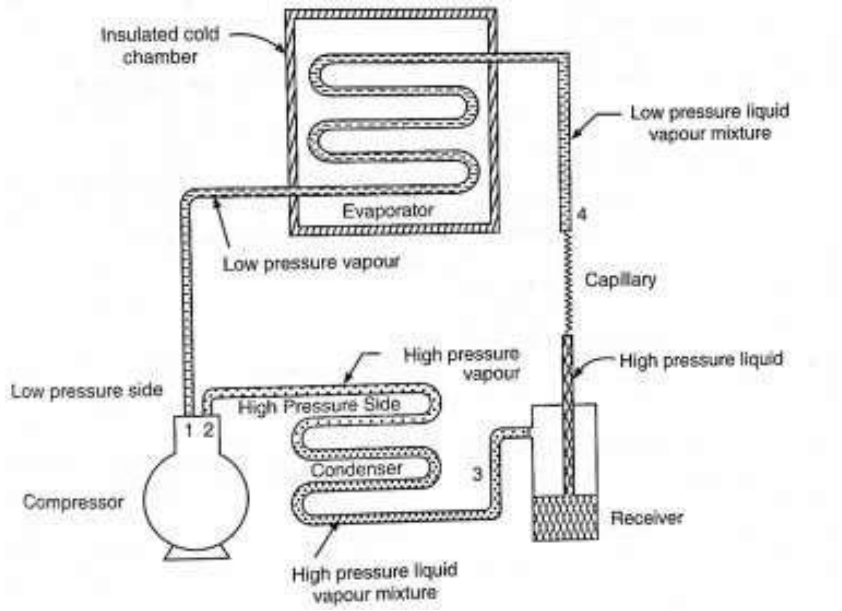
## Coefficient of Performance

1. The efficiency of a refrigerator and heat pump is expressed in terms of the coefficient of performance (COP).
2. The value of COP can be greater than unity.

3. Thermal efficiency can never be greater than 1.
4. The COP represents the running cost of refrigerator and heatpump.
5. Higher the value of COP lower the running cost.
6. Refrigerator is a cyclic device which is used to maintain lower temperature as compared to surrounding temperature.

**Q.6 Explain construction and working of domestic refrigerator.**

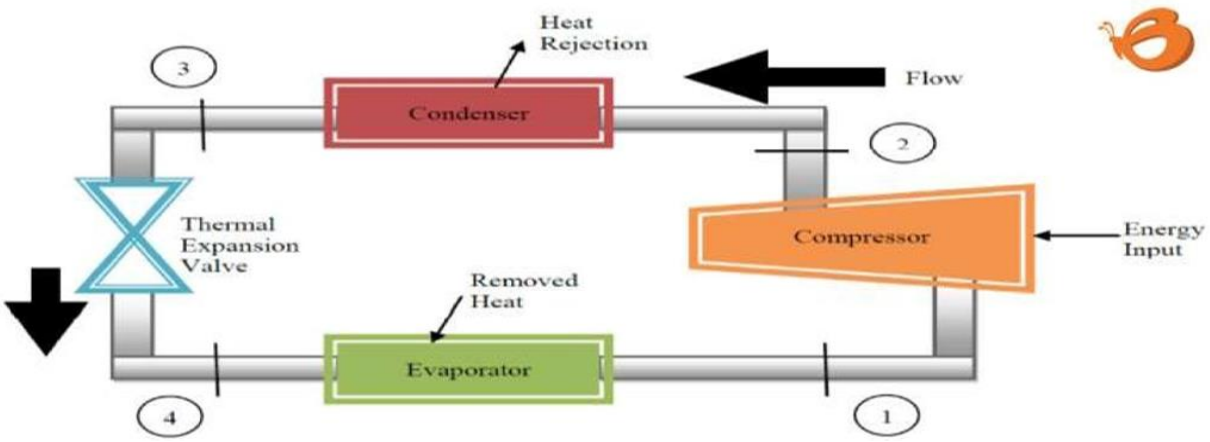
**Ans:** Refrigerator is a cyclic device which is used to maintain **lower temperature** as compared to surrounding temperature.




1. **COMPRESSOR:**

i) It is a mechanical device which transfers mechanical energy to working fluids i.e. refrigerant which is coming from evaporator.

ii) Compressor raises the pressure and temperature of the refrigerant.



## 2. CONDENSER:

i) It is a type of heat exchanger.

ii) The refrigerant enters into the condenser from the compressor.

iii) Condenser rejects the heat from working fluid (refrigerant) by means cooling coils made up of copper into the atmosphere.

iv) Due to heat rejection from refrigerant, it converts from gaseous state to liquid state.

v) After condensing refrigerant goes into the expansion devices.

## 3. THROTTLING/EXPANSION DEVICES

i. In expansion valve the pressure and temperature decreases which comes from condenser.

ii) It also regulates the flow of refrigerant into the evaporator and maintains the flow rate equal to the rate of evaporation in the evaporator.

iii) We can regulate and control the temperature of refrigerator using expansion devices by varying the opening as per our requirements.

iv) Refrigerant comes from throttling device enters into the evaporator at very

v) low temp and pressure.

vi) In evaporator refrigerant goes through cooling coils and heat is absorbed by the refrigerant.

vii) Due to this temperature of the refrigerant increases and liquid refrigerant expends and converts into vapours after that refrigerant goes to the compressor.

viii) Evaporator works as a heat exchanger between storage space and cooling coils.

ix) This cycle repeats continuously.

## Good practices to minimize the amount of energy consumed by refrigerator

1. Open the refrigerator door the fewest times possible for the shortest duration possible.

2. Cool the hot foods to room temperature first before putting them into the refrigerator.
3. Check the door gasket for leaks
4. Avoid unnecessarily low temperature settings.
5. Avoid excessive ice build-up on the interior surfaces of the evaporator.

**Q.7 Define the term 'air-conditioning'. What are the different applications of air- conditioning?**

**Ans:**

- **Air-Conditioning** is a process of controlling air temperature, humidity, ventilation, filtration and air circulation in a space **(Building or Vehicle).**

*Applications of air- conditioning:*

- Residential and office buildings
- Hospitals and cinema halls
- Libraries, museums, computer canters
- Transport vehicles : Car, bus, aircraft etc
- Food and process industries

**Q.8 Define the following**

**(i)Dry Air (ii) Atmospheric air (iii) Saturated air**

**Ans:**

**(i) Dry air :** It is a mixture of nitrogen, oxygen, and small amounts of some other gases.

**(ii) Atmospheric air :** Air in the atmosphere normally contains some **water vapor** (or *moisture*), **number of pollutants** and

referred as **atmospheric air.**

**(iii) Saturated air :** Saturated air is air that holds watervapor at its **highest level** i.e. just about to condense.

**(iv)**

**Q.9 Define the following**

**(i) specific humidity (ii) relative humidity**

**Ans:**

**(i) specific humidity:**

- It is also known as absolute humidity or humidity ratio and denoted by $\omega$.
- Specific humidity can be defined as the mass of water vapor present in a unit mass of dry air.

$$\omega = \frac{\text{mass of w.v.}}{\text{mass of d.a.}}$$

Unit
kg of water vapour / kg of dry air

$$\Rightarrow \omega = \frac{m_v}{m_a}$$

$$\Rightarrow \omega = \frac{V/v_v}{V/v_a}$$

$$\Rightarrow \omega = \frac{v_a}{v_v}$$

**ii) Relative humidity**

- **Relative humidity (RH)** is a measure of how much water vapor is in a water-air mixture compared to the maximumamount possible.

$$\phi = \frac{actual\ mass\ of\ water\ vapour\ \ in\ a\ given\ volume}{maximum\ mass\ of\ water\ vapour\ in\ a\ given\ volume}$$

- RH is a ratio of the humidity ratio of a particular water-air mixture compared to the saturation humidity ratio at a given temperature.

**Q.10 What is Psychrometry?**

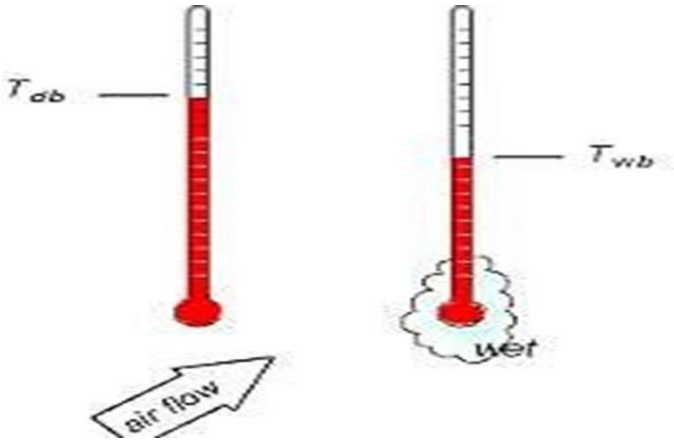
**Ans:**

- Moist air is the mixture of **water vapour and dry air**.
- The properties of moist air are called **Psychrometricproperties.**
- The science in which we deal with the **Psychrometricproperties** is known as **psychrometry**.
-

**Q.5 Define the following: (i) Dry Bulb Temperature (ii)Wet Bulb Temperature (iii) Dew point Temperature**

**Ans:**

1. In psychrometry, a psychrometer comprises of a dry bulb and a wet bulb thermometer.




**(i) Dry Bulb Temperature (Tdb or T)**

The dry bulb thermometer has bare bulb which is directly exposed to air and measure the actual temperature.

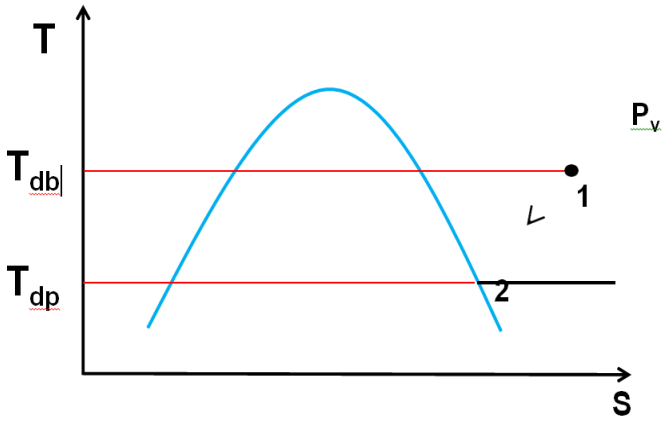
### ii) Wet Bulb Temperature (Twb)

The bulb of wet bulb thermometer is covered by a wick

thoroughly wetted by water.

The temperature which is measured by the wet wick covered bulb is known as wet bulb temperature.

### iii) Dew point Temperature




- The air in atmosphere contain moisture (water vapour).
- If we reduce the temperature of the air, moisture get condense.
- The temperature at which **first drop of dew is formed or condensation begins** when the air is cooled at **constant pressure** is known as dew point temperature.
- Denoted by $T_{dp}$.

## Q.6 Explain the human comfort. What are the conditions for comfort air conditioning?

**Ans:**

- Human Comfort refers to the control of temperature and humidity of air and its circulation.

- So that the resulting environment becomes human friendly.

- **General human comfort conditions are to maintained in the range of**

- **Te**mperatures 22 °C to 27 °C
- Relative humidity 40% to 60%
- Air velocity 5 m/min to 8 m/min

## Q.7 With the help of neat sketch describe the working of window type air-conditioner.

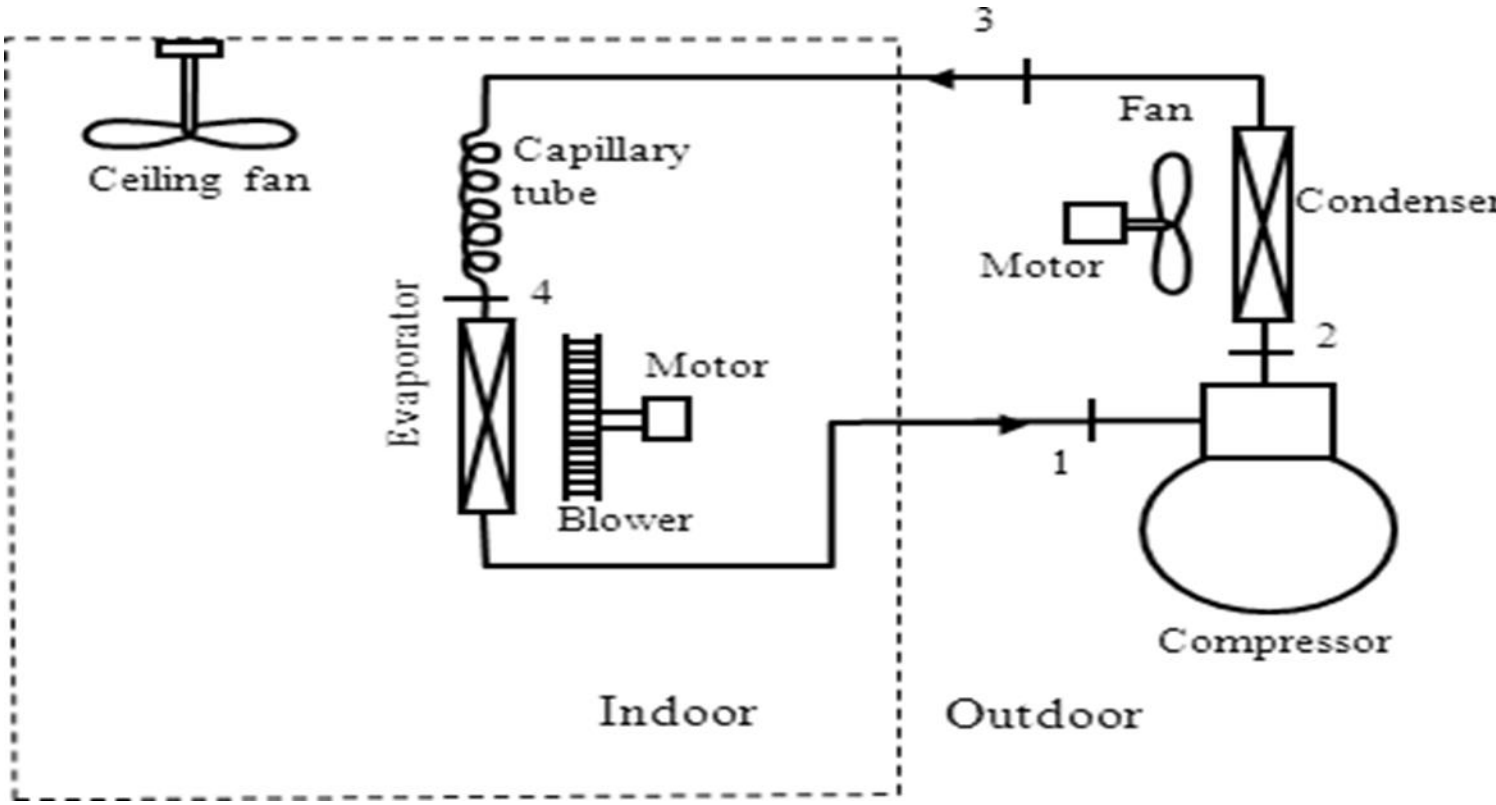
**Ans:**

- Air-Conditioning is a process of controlling air temperature,humidity, quality and ventilation in a space (Building or Vehicle).

- **Air conditioning can be used in both domestic and commercial environments.**

- This process is most commonly used to achieve a more comfortable interior environment, typically for humans and other animals.

1) Window air conditioner is sometimes referred to as room air conditioner.
2) It is the simplest form of an air conditioning system and is mounted on windows or walls.
3) It is a single unit that is assembled in a casing where all the components are located.


## Compressor

- The refrigerant enters the compressor at low temperature and pressure in a gaseous state.
- In compressor **temperature and pressure of refrigerant increases**.
- The refrigerant leaves the compressor and enters to the condenser.
- Since this process requires work, an electric motor may be used.

## Condenser

- It is a kind of heat exchanger in which refrigerant of high pressure and temperature enters which coming fromcompressor. .
- **The function of the condenser in a refrigeration system is to transfer heat from the refrigerant to another medium, such as air.**
- By rejecting heat, the gaseous refrigerant condenses to liquid inside the condenser.

### Throttling/Expansion valve:

- High pressure refrigerant from the condenser enters the throttling device, the pressure and temperature of the refrigerant drops down suddenly.
- Throttling valve also controls the amount of the refrigerant flowing through it.

### Evaporator

- It is a kind of heat exchanger in which refrigerant of **low** pressure and temperature enters which is coming from throttling valve.
- *The function of the evaporator is to absorb heat by the* **refrigerant from the space to be cooled.**
- By absorbing heat, the refrigerant converts from liquid state to gaseous state.
- **Filter Drier** is used to remove the moisture from the refrigerant.
- **Drain Pan** is used to contain the water that condensate from the cooling coil and is discharged out to the outdoor.
- **Propeller Fan** is used in air-cooled condenser to help move the air molecules over the surface of the condensing coil.
- **Fan Motor** is located here. It has a double shaft where the indoor blower and outdoor propeller fan are connected together.

# Specification

A window air-conditioner is normally specified by the following parameters:

- Capacity : 1, 1.5 and 2 ton etc
- Overall dimensions : length x width x height

- Power supply : AC, 220-240 volts
- Control : site or remote

# BUDDHA SERIES

## (Unit Wise Solved Question & Answers)

## Course – B.Tech

## College – Buddha Institute of Technology

**(AKTU CODE-525)**

## Department: ASH 1

## Subject: Fundamental of Mechanical Engineering (BME101)

## Faculty Name: Mohd Faizan / S .B Lal

## Unit - 4

**Unit – IV**

**Introduction to Fluid Mechanics and Applications**

**SYLLABUS:**

**Introduction:** Fluids properties, pressure, density, dynamic and kinematic viscosity, specific gravity, Newtonian and Non Newtonian fluid, Pascal's Law, Continuity Equation, Bernoulli's Equation and its applications, Basic Numerical problems.

Working principles of hydraulic turbines & pumps and their classifications, hydraulic accumulators, hydraulic lift and their applications.

## Introduction

STATES OF MATTER

- A matter exists in either the solid state or the fluid state.
- The fluid state is further divided into
  - Liquid state
  - Gaseous state
- In fact the same matter may exist in any one of the three states i.e. solid, liquid and gaseous.
- For example water occurs in a liquid state, may also occur in solid state as ice and in a gaseous state as vapour.
- In solids the molecules are very closely spaced.
- In liquids the spacing between the molecules is relatively large.
- In gases the space between the molecules is still larger.

3

## Fluid mechanics

- "Fluid mechanics is that branch of science which deals with the behavior of the fluids at rest as well as in motion."

- In general the scope of fluid mechanics is very wide which includes the study of all liquids and gases.

- It has applications in mechanical, civil, chemical and biomedical engineering, biology etc.

## Q .1 Define fluid and what is difference between gas and liquid?

➢Fluid may be defined as a substance which is capable of flowing. It has no definite shape of its own, but conforms to the shape of the containing vessel.

or

❖**"A fluid is a substance which deforms continuously under the action of tangential or shear force."**

❖**A liquid** is a fluid, which possesses a definite volume, which may vary slightly with temperature and pressure.

❖**A gas** is a fluid, which is compressible and possesses no definite volume but it always expands until its volume is equal to that of the container.

❖Examples of fluids are : Water, Milk, Kerosene, Petrol, Gases etc.

## Q. 2 Define the following fluid properties of a Fluid.

1. Pressure
2. Density
3. Specific Weight(**weight density)**
4. Specific Gravity
5. **Specific volume**

## 1.Pressure (P)

❖"It is defined as normal force per unit area."

$$P = \frac{F}{A}$$

❖It is a scalar quantity.

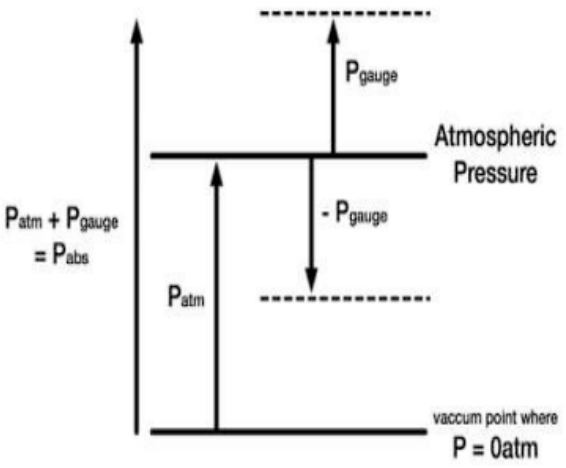
❖Units of Pressure :

➢ $N/m^2$

➢ Pascal (Pa) (1 Pa = 1 $N/m^2$)

➢ atm (1 atm = 101325 Pa = 101.325 kPa)

➢Bar (1 bar =$10^5$ Pa = $10^5$ $N/m^2$



## 2. Density($\rho$) or mass density

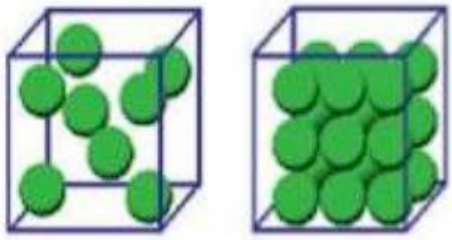
❖"It is defined as mass per unit volume of the substance."

$$\rho = \frac{m}{V}$$

❖Units of density

➢Kg/$m^3$

➢g/$cm^3$ or g/cc (1 g/cc = $10^3$ kg/$m^3$)



❖For example

➢ $\rho_{water}$ = 1000 kg/$m^3$

➢$\rho_{air}$ = 1.2 kg/$m^3$

➢$\rho_{steel}$ = 7850 kg/$m^3$

## 3.Specific Weight (ω) or weight density

❖"It is defined as weight per unit volume ."

$$\omega = \frac{weight}{Volume} = \frac{mg}{V} = \rho g \qquad [\rho = \frac{m}{V}]$$

❖Unit of specific weight is N/$m^3$

## 4.Specific Gravity

❖" It is defined as the density of the fluid w.r.t. the density of standard fluid."

$$\textbf{Specific Gravity(s)} = \frac{density\ of\ a\ fluid}{density\ of\ standartd\ fluid}$$

➢For liquid, standard fluid is water ( at 4 °C(**39.2 °F**), 1 atm, 1000 kg/$m^3$).

➢For gases, standard fluid is Air/$H_2$.

# 5. Specific volume(v)

❖"It is defined as volume per mass unit of the substance."

$$v = \frac{V}{m}$$

❖Units of Specific volume

➢$m^3/Kg$

**Problem 1.1** *Calculate the specific weight, density and specific gravity of one litre of a liquid which weighs 7 N.*

**Solution.** Given :

$$\text{Volume} = 1 \text{ litre} = \frac{1}{1000} \text{ m}^3 \quad \left(\because \ 1 \text{ litre} = \frac{1}{1000} \text{ m}^3 \text{ or } 1 \text{ litre} = 1000 \text{ cm}^3\right)$$

$$\text{Weight} = 7 \text{ N}$$

(*i*) Specific weight ($w$) $= \dfrac{\text{Weight}}{\text{Volume}} = \dfrac{7 \text{ N}}{\left(\frac{1}{1000}\right) \text{m}^3} = \mathbf{7000 \text{ N/m}^3}$**. Ans.**

(*ii*) Density ($\rho$) $= \dfrac{w}{g} = \dfrac{7000}{9.81} \text{ kg/m}^3 = \mathbf{713.5 \text{ kg/m}^3}$**. Ans.**

(*iii*) Specific gravity $= \dfrac{\text{Density of liquid}}{\text{Density of water}} = \dfrac{713.5}{1000}$ $\{\because$ Density of water = 1000 kg/m$^3\}$

$= \mathbf{0.7135}$**. Ans.**

**Problem 1.2** *Calculate the density, specific weight and weight of one litre of petrol of specific gravity = 0.7*

**Solution.** Given : $\text{Volume} = 1 \text{ litre} = 1 \times 1000 \text{ cm}^3 = \dfrac{1000}{10^6} \text{ m}^3 = 0.001 \text{ m}^3$

Sp. gravity $S = 0.7$

(*i*) *Density* ($\rho$)

Using equation (1.1*A*),

*Density* ($\rho$) $= S \times 1000 \text{ kg/m}^3 = 0.7 \times 1000 = \mathbf{700 \text{ kg/m}^3}$**. Ans.**

(*ii*) *Specific weight* ($w$)

Using equation (1.1), $w = \rho \times g = 700 \times 9.81 \text{ N/m}^3 = \mathbf{6867 \text{ N/m}^3}$**. Ans.**

(*iii*) *Weight* ($W$)

We know that specific weight $= \dfrac{\text{Weight}}{\text{Volume}}$

or $w = \dfrac{W}{0.001}$ or $6867 = \dfrac{W}{0.001}$

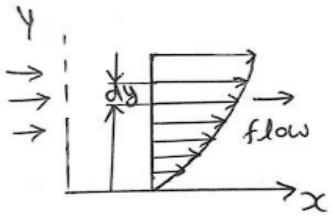
$\therefore$ $W = 6867 \times 0.001 = \mathbf{6.867 \text{ N}}$**. Ans.**

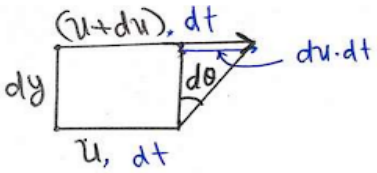
## Q.5 Explain Viscosity.

- "Two adjacent layers of the fluid **resist** the motion of each other such a fundamental property of the fluid is known as **viscosity or dynamic viscosity**" denoted by **μ**.
- Therefore the frictional force between the adjacent layers is known as viscous shear force.

$$\tan d\Theta = \frac{du.dt}{dy}$$

if $d\Theta$ is very small $d\Theta = \frac{du.dt}{dy}$




$$\frac{d\Theta}{dt} = \frac{du}{dy}$$

Where $\frac{d\Theta}{dt}$ = Rate of angular(shear) deformation and $\frac{du}{dy}$ = Velocity gradient.

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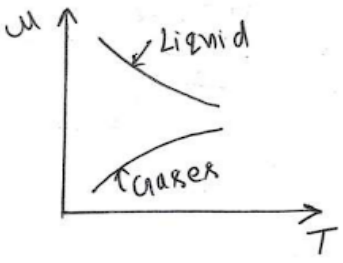
## Viscosity.....

- Basic cause of viscosity is **cohesive forces** between the molecules.
- Because in case of liquid cohesive force is high and in case of gases cohesive force is very less.
- Therefore viscosity of liquid is very high as compared to viscosity of gases.

## Dependency of Viscosity on Temperature

- Viscosity of **liquid** decreases with increase in temperature.[if T↑ then cohesion ↓]




- Viscosity of **gases** increases with increase in temperature.[if T↑ then randomness↑]

➢ $C = \sqrt{\frac{3RT}{m}} = \sqrt{\frac{3Pv}{m}}$

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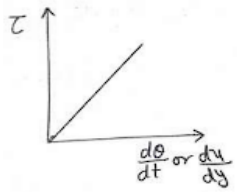
## Q .6 State the Newton's law of Viscosity.

❖According to Newton's law of viscosity "Shear stress between the layers of fluid is directly proportional to rate of shear deformation."

$\tau \propto \frac{d\Theta}{dt}$ or $\tau \propto \frac{du}{dy}$ [Because $\frac{d\Theta}{dt} = \frac{du}{dy}$]

$\tau = \mu \frac{du}{dy}$




❖Where **μ** is proportionality constant(**property of fluid**) which is known as viscosity or dynamic viscosity.

❖Unit of viscosity

➢MKS : $\frac{N-s}{m^2} = \frac{kg-m}{s^2} \times \frac{s}{m^2} = \frac{kg}{m-s}$ [F = ma]

➢**CGS :** $\frac{gm}{cm-s} = \frac{10^{-3}kg}{10^{-2}\,m-s} = 0.1\,\frac{kg}{m-s} = 0.1\,\frac{N-s}{m^2}$

❖ $\frac{gm}{cm-s}$ = 1 Poise = 0.1 $\frac{N-s}{m^2}$

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## Q.7 Define Kinematic Viscosity.

❖"Ratio of dynamic Viscosity and density is called Kinematic Viscosity, denoted by **ν.**

$$\nu = \frac{\mu}{\rho}$$

❖Unit of Kinematic Viscosity

➢MKS : $m^2/s$

➢CGS : $cm^2/s$

$1\,\frac{cm^2}{s} = 10^{-4}\,\frac{m^2}{s} = 1$ stoke

## Q .8 Define Newtonian and Non Newtonian fluids.

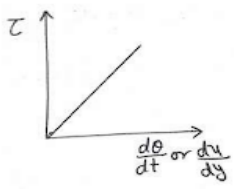
❖**NEWTONIAN FLUID :** "All the fluids which obey Newton's law of viscosity are known as Newtonian fluids."

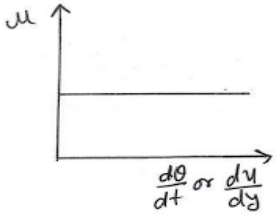
❖There is a linear relation between magnitude of τ and $\frac{d\Theta}{dt}$.

❖Example : Air, water, kerosene, petrol etc.

$\tau = \mu \frac{du}{dy}$ Or $\tau = \mu \frac{d\Theta}{dt}$

$\mu = \tau / (\frac{d\Theta}{dt})$




**μ is the slope of** ($\tau$- $\frac{d\Theta}{dt}$) diagram.

❖ Note: In Newtonian fluid the viscosity does not change for same fluid.

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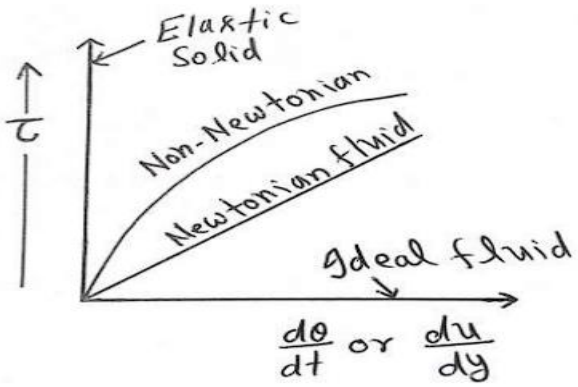
❖**Non Newtonian fluids**:-The fluids which do not follow Newton's law viscosity are known as Non-Newtonian Fluid.

❖There is a non-linear relation between magnitude of $\tau$ and $\frac{d\theta}{dt}$.




## Q .9 Differentiate between Real and Ideal fluids.

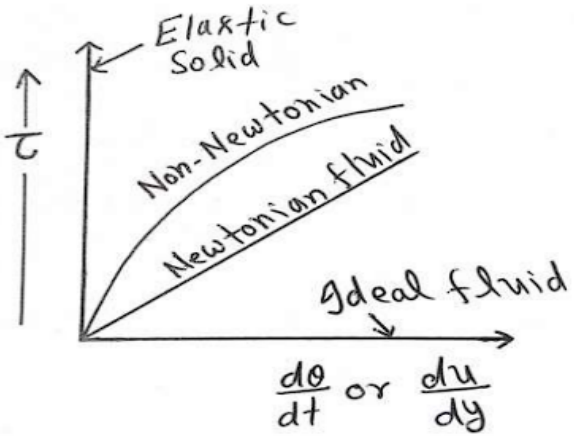
❖**IDEAL FLUID:-**Incompressible fluid having zero viscosity is called ideal fluid($\tau = 0$).

❖**Ideal fluid** do not actually exist in nature.

❖It is represented by horizontal line on ($\tau$-$\frac{d\theta}{dt}$) diagram .

❖**Real fluid: Fluid** that have viscosity($\mu > 0$) and their motion known as viscous flow.

❖All the fluids in actual are real fluids.




## Pascal's Law and its applications

❖In a fluid at rest the intensity of pressure is same in all directions.

❖In other words, when a certain pressure is applied in a fluid at rest, the pressure is equally transmitted in all the directions.

$$P = \frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$\frac{F_2}{F_1} = \frac{A_2}{A_1}$$

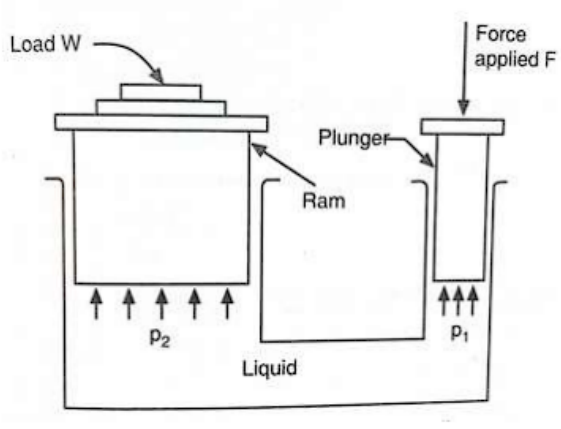
❖Applications of Pascal's law are

➢Hydraulic lift

➢Hydraulic Jacks

➢Hydraulic brakes

➢Hydraulic pumps



# CONTINUITY EQUATION

- This equation is based on the principle of conservation of mass.
- The quantity of fluid per second is constant at all the cross sections through the pipe.

- Flow Rate → Volume flow rate $(\frac{m^3}{s}) = \frac{AL}{s} =$ A V  [V = velocity]
- Flow Rate → mass flow rate $(\frac{kg}{s}) = \frac{\rho AL}{s} = \rho$ A V

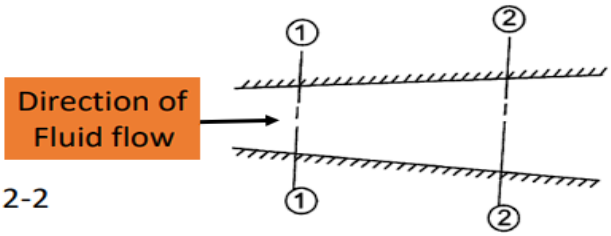
- Consider two cross sections as shown in figure:

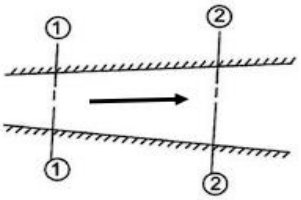
Let $V_1$ = Average velocity at cross-section 1-1

$\rho_1$ = density at section 1-1

$A_1$ = Area of pipe at section 1-1

and $V_2, \rho_2, A_2$ are corresponding values at section 2-2




- Rate of flow at section at 1-1 = $\rho_1 A_1 V_1$
- Rate of flow at section at 2-2 = $\rho_2 A_2 V_2$
- According to law of conservation of mass:
  Rate of flow at section at **1-1** = Rate of flow at section at **2-2**

$$\rho_1 A_1 V_1 = \rho_2 A_2 V_2 = \text{Constant}$$

- This **Continuity Equation is** applicable for the **compressible** fluids .
- If the fluid is **In-compressible**, i.e. water then $\rho_1 = \rho_2$ and continuity equation becomes:

$$Q = A_1 V_1 = A_2 V_2 = \text{Constant}$$

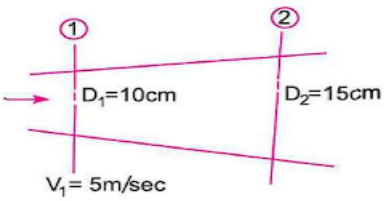
**Problem** —— *The diameters of a pipe at the sections 1 and 2 are 10 cm and 15 cm respectively. Find the discharge through the pipe if the velocity of water flowing through the pipe at section 1 is 5 m/s. Determine also the velocity at section 2.*

**Solution.** Given :

At section 1, $D_1 = 10$ cm $= 0.1$ m

$$A_1 = \frac{\pi}{4}(D_1^2) = \frac{\pi}{4}(.1)^2 = 0.007854 \text{ m}^2$$

$V_1 = 5$ m/s.




At section 2, $D_2 = 15$ cm $= 0.15$ m

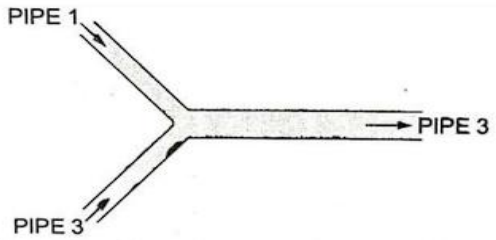
$$A_2 = \frac{\pi}{4}(.15)^2 = 0.01767 \text{ m}^2$$

**Q = ? and $V_2$ = ?**

## Problem

Consider steady flow of water in a situation where two pipe lines (pipe 1 and pipe 2) combine into a single pipe line (pipe 3) as shown in figure. The cross-sectional area of all three pipelines are constant. The following data is given

| Pipe number | Area ($m^2$) | Velocity (m/s) |
|---|---|---|
| 1 | 1 | 1 |
| 2 | 2 | 2 |
| 3 | 2.5 | ? |




Assuming the water properties and the velocities to be uniform across the cross-section of the inlets and the outlet, the exit velocity (in m/s) in pipe 3 is

(a) 1 (b) 1.5
(c) 2 (d) 2.5

[2009 : 2 Marks]

## Solution

$$Q_1 + Q_2 = Q_3$$
$$A_1V_1 + A_2V_2 = A_3V_3$$
$$1 + 4 = 2.5 \times V_3$$
$$V_3 = 2 \text{ m/s}$$

## Bernoulli's Equation

❖ **FLUID DYNAMICS:- Study of motion of fluid flow along with force causing the flow.**

The fluid dynamics is governed by Newton's second law of motion.

**F = ma**

Where
F = Net external force,
m = Mass of the fluid element on which force acts ,
a = total acceleration

❖ **Forces acting on the fluid in Motion: A fluid may subjected be to various forces during motion such as**

1. Gravity force ($F_g$)
2. Pressure force ($F_p$)
1. Viscous force ($F_v$)
2. Turbulence force ($F_t$)
3. Surface tension ($F_s$)
4. Elastic force or compressibility ($F_e$)

According to Newton's second law

$F_g + F_p + F_v + F_t + F_s + F_e = F_i$ Eqn (1)

Where $\mathbf{F_i}$ is inertia force , $\mathbf{F_i = ma.}$

**In most of the fluids flow, surface tension force and the compressibility force are not significant.**

Therefore, $F_s = 0$ and $F_e = 0$

**So Eqn 1 becomes $F_g + F_p + F_v + F_t = F_i$ Eqn (2)**

If flow is laminar then $F_t = 0$

Eqn 2 becomes $F_g + F_p + F_v = F_i$ Eqn (3)



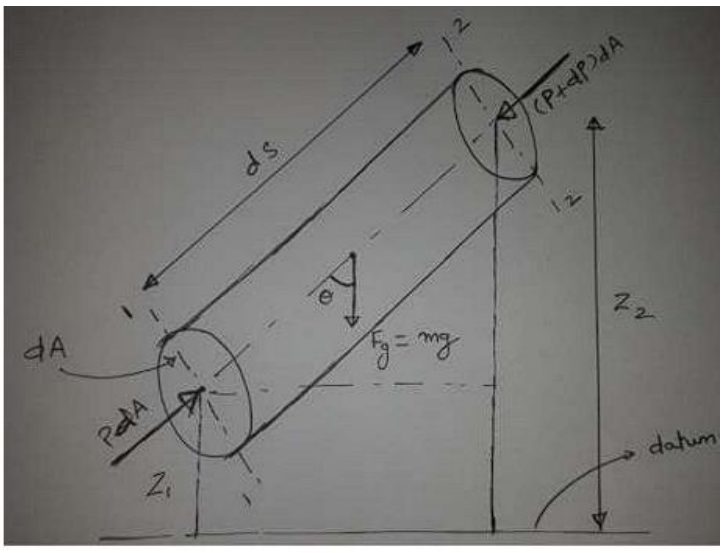
Assumptions of Bernoulli's Equation

1. The flow must be steady
2. Incompressible flow
3. Non-viscous or ideal fluid
4. Irrotational flow
5. Flow only along the stream line

Consider a fluid element is flowing along a stream line of cross-sectional area **dA** between two arbitrarily chosen sections **1-1** and **2-2**.

Suppose in time interval **dt**, the fluid element moves through a short distance **ds**.

Let $\mathbf{Z_1}$ and $\mathbf{Z_2}$ be the distance of a point on sections **1-1** and **2-2** from datum.




Suppose $\mathbf{P_1}$ and $\mathbf{P_2}$ be the pressure and $\mathbf{V_1}$ and $\mathbf{V_2}$ are the velocities at sections **1-1** and **2-2** respectively.

From Euler's equation (4)

$F_p + F_g = F_i$

$$PdA - (P + dP)\,dA - mg\,Cos\theta = m\,a$$

Where $a = v.\frac{dv}{ds} + \frac{dv}{dt}$

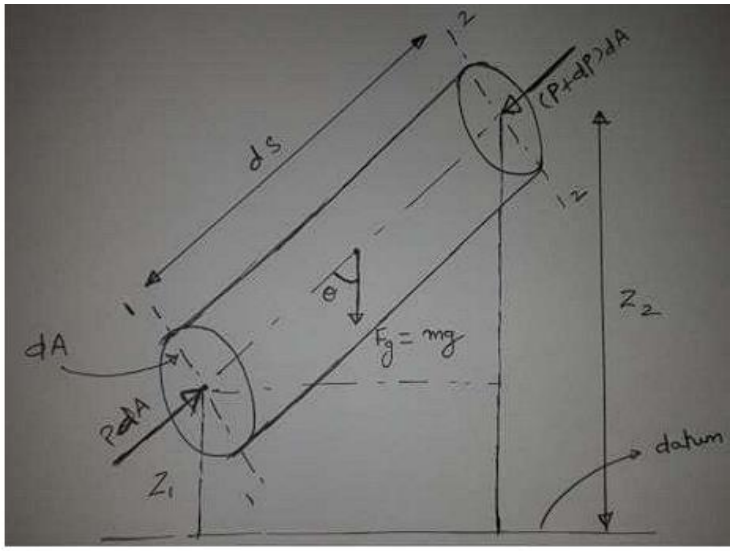
Convective acceleration

Temporal acceleration

for steady flow, $\frac{dv}{dt} = 0$

therefore,

$$PdA - (P + dP)\,dA - mg\,Cos\theta = m\,v.\frac{dv}{ds}$$




$$PdA - (P + dP)\,dA - mg\,Cos\theta = m\,v.\frac{dv}{ds}$$

but $m = \rho.ds.dA$

$$-dP.dA - \rho g dA.ds Cos\theta = (\rho ds.dA).v.\frac{dv}{ds}$$

From figure , $Z_2 - Z_1 = dZ = ds Cos\theta$

$$-dP.dA - \rho g dA.dZ = (\rho ds.dA).v.\frac{dv}{ds}$$

$$-dP - \rho g.dZ = \rho.v.dv$$

$$\frac{-dP}{\rho} - g.dz = v.dv$$

$$\int \frac{dP}{\rho} + \int v.dv + \int g.dz = 0$$

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$$\int \frac{dP}{\rho} + \int v.dv + \int g.dz = 0$$

Since flow is incompressible, mass density (ρ) of the fluid will be independent of pressure. Hence

$$\frac{P_2 - P_1}{\rho} + \frac{V_2^2 - V_1^2}{2} + g(Z_2 - Z_1) = 0$$

$$\frac{P_1}{\rho} + \frac{V_1^2}{2} + gZ_1 = \frac{P_2}{\rho} + \frac{V_2^2}{2} + gZ_2 \quad \text{——————} \quad \text{Eqn (5)}$$

$$\frac{P_1}{\omega} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\omega} + \frac{V_2^2}{2g} + Z_2 \quad \text{——————} \quad \text{Eqn (6)}$$

Where ω = specific weight or weight density = ρg

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$$\frac{P_1}{\rho} + \frac{V_1^2}{2} + gZ_1 = \frac{P_2}{\rho} + \frac{V_2^2}{2} + gZ_2 \quad \text{——————} \quad \text{Eqn (5)}$$

$$\frac{P_1}{\omega} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\omega} + \frac{V_2^2}{2g} + Z_2 \quad \text{——————} \quad \text{Eqn (6)}$$

$$\frac{P}{\omega} + \frac{V^2}{2g} + Z = \text{Constant} \quad \text{——————} \quad \text{Eqn (7)}$$

Equation **(5)**, **(6)** and **(7)** are known as Bernoulli's equation for steady incompressible flow of an ideal (non-viscous) fluid.

The term $\frac{P}{\omega} = \frac{P}{\rho g}$ is known as pressure head or static head.

$\frac{V^2}{2g}$ is known as velocity head or kinetic head.

**Z** is known as potential head or datum head.

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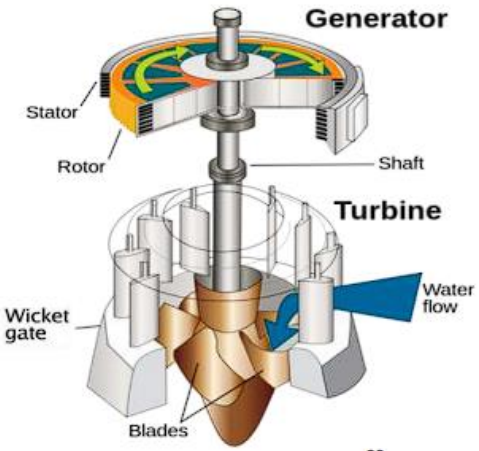
## Applications of Bernoulli's Equation

- Venturi Meter
- Orifice Meter
- Pitot Tube

- Hydraulic machines are defined as those machines which convert either *hydraulic energy* into *mechanical energy* or *mechanical* energy **into** *hydraulic energy*.
- Hydraulic Energy- Energy possessed by water is called hydraulic energy.
- Mechanical Energy- power produced at shaft of turbine is called mechanical energy.
- Mechanical energy can be further converted into electrical energy with the help of generator.

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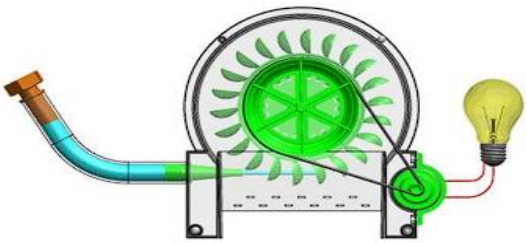
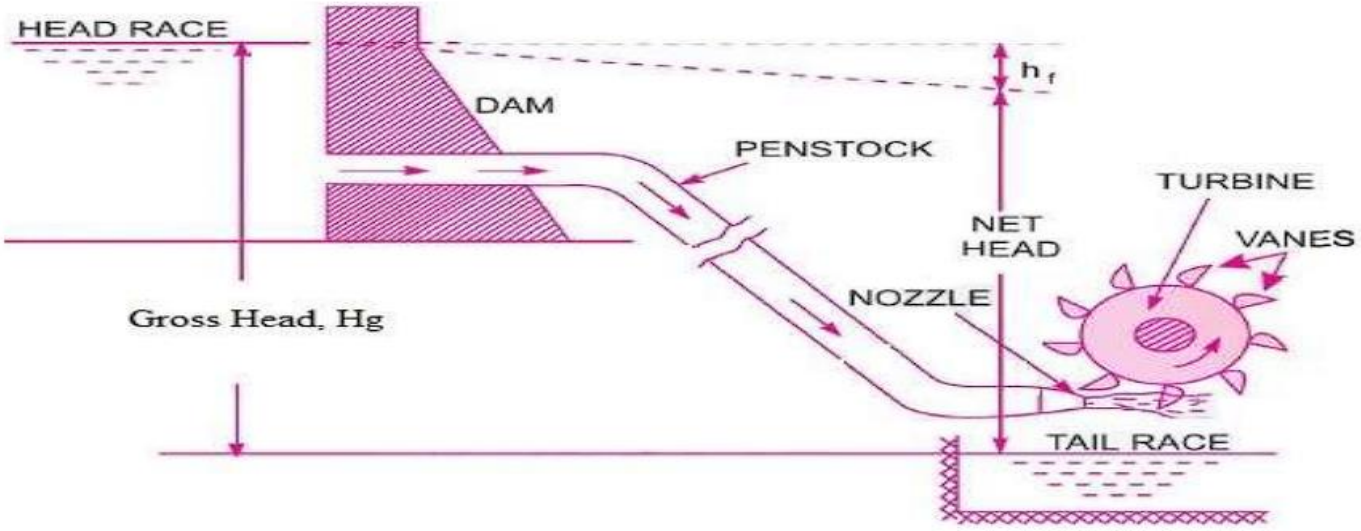
➢ The **hydraulic machines** which converts the hydraulic energy into mechanical energy, are called as **turbines**.



➢ The **hydraulic machines** which converts mechanical energy into hydraulic energy , are called as **pump**.


## *General Layout of Hydro-electric power plant*




## CLASSIFICATION OF TURBINE

The turbines are classified in the following ways:-

1. According to the type of energy available at inlet

   (a) **Impulse turbine** (b) **Reaction turbine**

❖ If at the inlet of the turbine , **only kinetic energy is available**, the turbine is known as ***impulse turbine***.

Eg. Pelton Turbine.

❖ If at the inlet of the turbine, water possesses **kinetic energy** as well as **pressure energy**, the turbine is known as ***reaction turbine***.

eg. Francis turbine, Kaplan turbine.

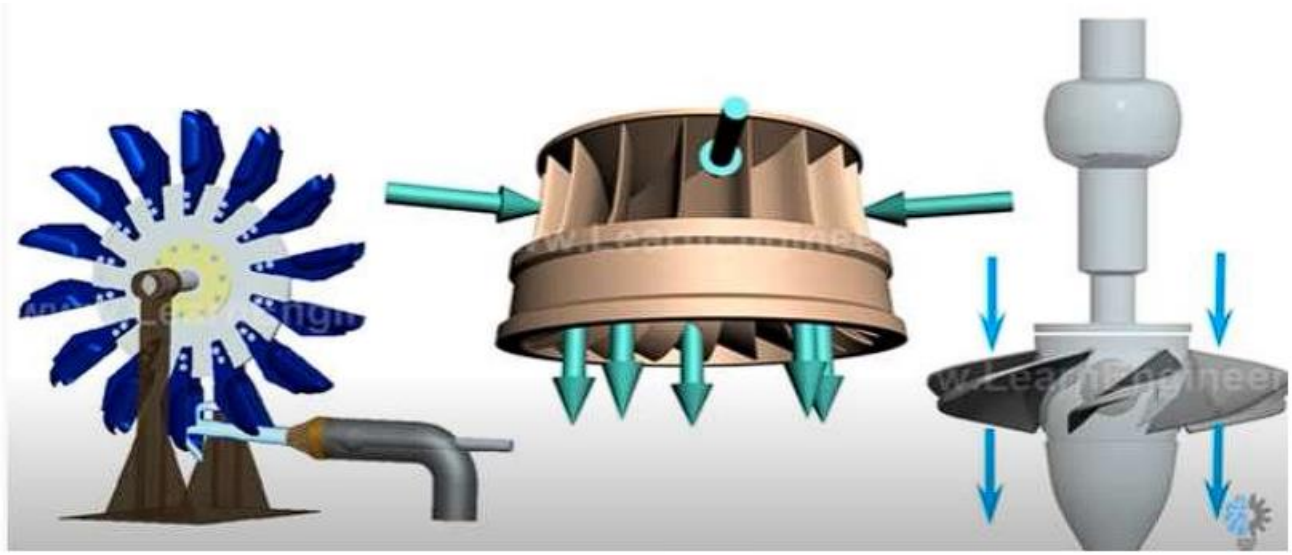
2. According to the *direction of flow* of water through runner:

a) Tangential flow turbine (e.g. Pelton Turbine)

b) Radial flow turbine (e.g. Francis Turbine)

c) Axial flow turbine (e.g. Kaplan and propeller Turbine)

d) Mixed flow turbine (e.g. Modern Francis Turbine)



**Pelton Turbine** **Francis Turbine** **Kaplan Turbine**

3. According to the head available at inlet of turbine

a) High head turbine( 150m< H<2000m) e.g.. Pelton turbine

b) Medium Head turbine ( 30<H<150m) e.g. Francis Turbine

c) Low Head turbine ( H<30m) e.g.. Kaplan and propeller turbine

4. According to the specific speed of turbine

a) Low specific speed turbine, (Ns< 50) e.g. P.T.

b) Medium specific speed turbine,(50< Ns <250) e.g. F.T.

c) High specific speed turbine. (Ns > 250) e.g. K.T.

Mathematically,

$$N_s = \frac{N\sqrt{P}}{H^{5/4}}$$

where, N = normal speed of turbine in rpm
P = turbine power output in kW
H = net head of turbine in m

5. According to the position of shaft of turbine

a) Horizontal shaft turbine
b) Vertical shaft turbine

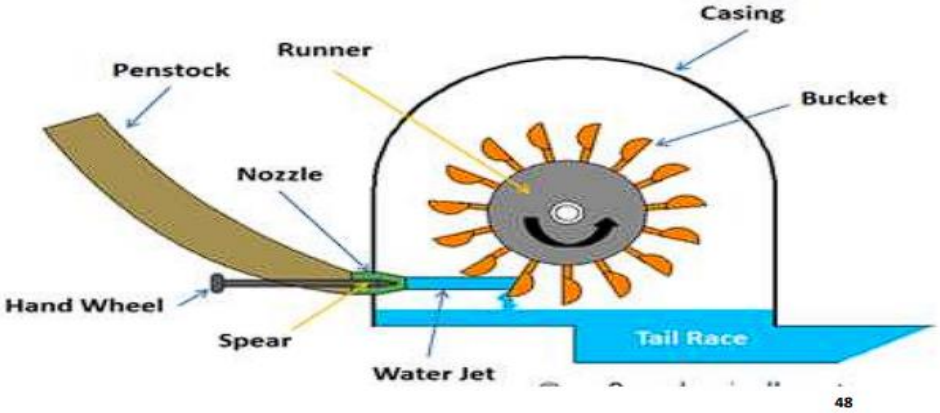
(Pelton turbine has horizontal shaft whereas the rest have vertical shaft)

6. According to name of originator
a) Pelton Turbine(Pelton Wheel)
b) Francis Turbine,
c) Kaplan Turbine.

## CONSTRUCTION AND WORKING OF IMPULSE TURBINES

### Main parts of Impulse turbine are :-

1. Nozzle and flow regulating device
2. Runner and bucket
3. casing

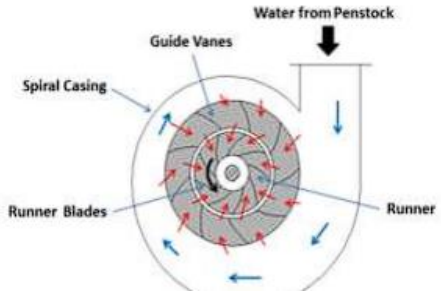


- Nozzle with guide mechanism- It is provided to convert the pressure energy into kinetic energy in the form of jet and it also regulates the quantity of water according to the load on turbine.
- Runner- A wheel of the turbine consist of series of buckets/blades/vanes mounted on its periphery.
- Casing- It is used to avoid accident and prevents the splashing of water. It does not perform any hydraulic function.
- The pressure throughout the turbine from inlet to outlet is **atmospheric** in case Impulse turbine.

## CONSTRUCTION AND WORKING OF REACTION TURBINES

Main parts of reaction turbine are :-

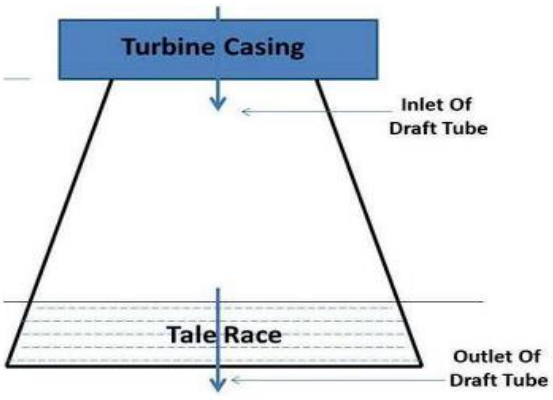
1. Casing
2. Guide mechanism
3. Runner
4. Draft tube




- Casing- In reaction turbine, casing and runner are always full of water. It is of spiral shape.
- Runner- A wheel of the turbine consist of series of buckets/blades/vanes mounted on its periphery.
- Guide mechanism- The guide vanes allow the water to strike the fixed blades on the runner without shock at inlet.

**Draft tube-** Draft Tube is a diverging tube fitted at the exit of runner of turbine and used to utilize the kinetic energy available with water at the exit of runner.

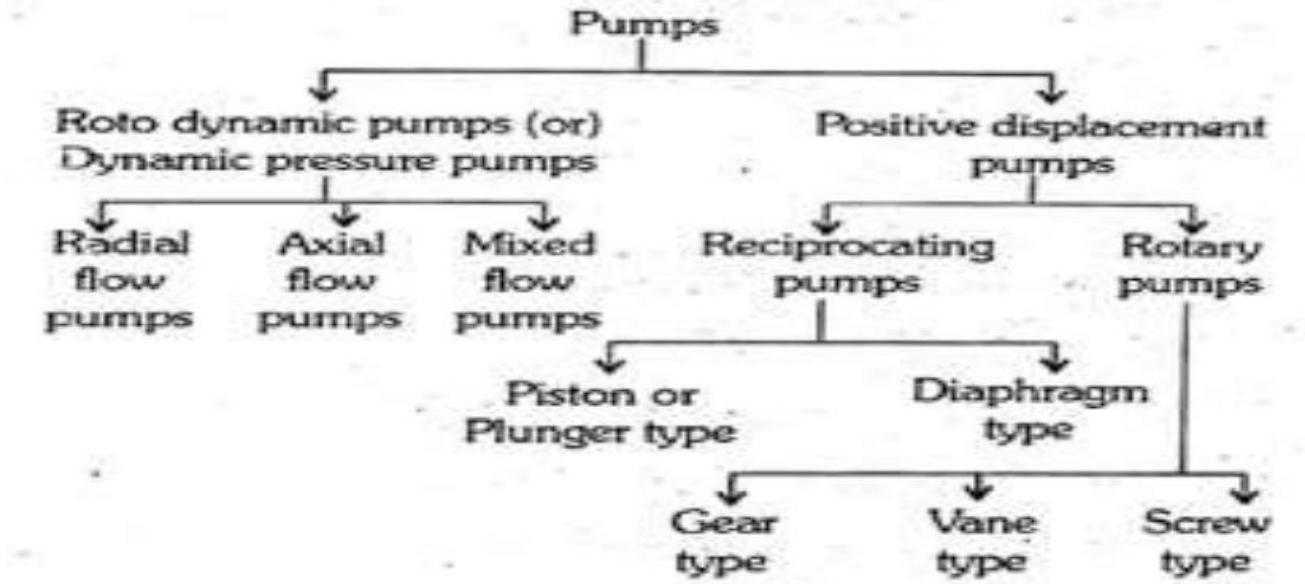
- Pressure head is increased by decreasing the exit velocity.
- Overall efficiency and the output of the turbine can be improved.



# PUMP

- The hydraulic machine which converts ***Mechanical energy*** *into* ***Hydraulic energy*** is known as pump.
- The hydraulic energy is in the form of ***Pressure Energy***.
- If the mechanical energy is converted into pressure energy by means of centrifugal force acting on the fluid, the hydraulic machine is called ***Centrifugal Pump***.
- The centrifugal pump works on the principle of ***forced vortex flow.***

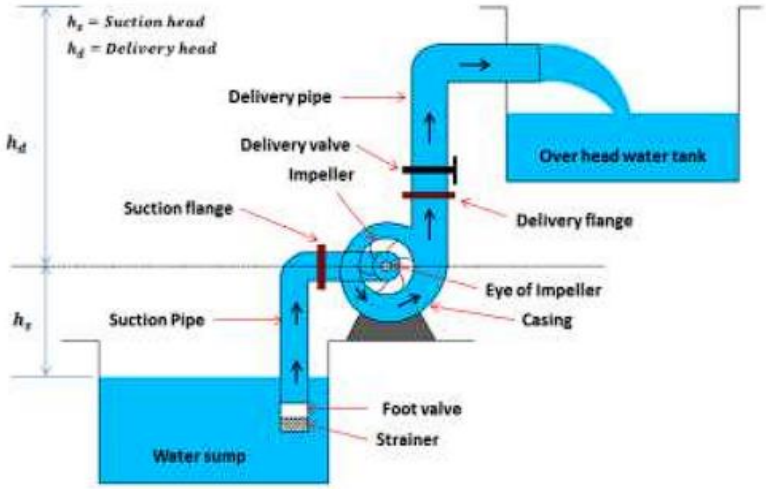
## CLASSIFICATION OF PUMP




## CENTRIFUGAL PUMP

Main parts of a C.P. are :-

1. Impeller
2. Casing
3. Suction pipe with foot valve and a strainer
4. Delivery pipe




Centrifugal Pump Working

- A centrifugal pump is a mechanical device designed to move a fluid by means of the transfer of rotational energy from one or more driven rotors, called impellers.

- Fluid enters the rapidly rotating impeller along its axis and is cast out by centrifugal force along its circumference through the impeller's vane tips.

- The centrifugal pump works on the principle of forced vertex flow which means that when a certain mass of liquid is rotated by an external torque, the rise in pressure head of the rotating liquid takes place.

**Impeller:** The rotating part of a centrifugal pump is called impeller. It consists of a series of backward curved vanes. The impeller is mounted on a shaft which is connected to the shaft of an electric motor.

**Casing:** the casing of a centrifugal pump is similar to the casing of a reaction turbine. It is an air tight passage surrounding the impeller and is designed in such a way that the kinetic energy of the water discharged at the outlet of the impeller is converted in to pressure energy before the water leaves the casing and enters the delivery pipe.

**Suction pipe with a foot valve and a strainer:** A pipe whose one end is connected to the inlet of the pump and other end dips in to water in a sump is known as suction pipe.

A foot valve which is a non-return valve or one-way type of valve is fitted at the lower end of the suction pipe. The foot valve opens only in the upward direction.

A strainer is also fitted at the lower end of the suction pipe. Delivery pipe: A pipe whose one end is connected to the outlet of the pump and the other end delivers the water at the required height is known as delivery pipe.

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## RECIPROCATING PUMP

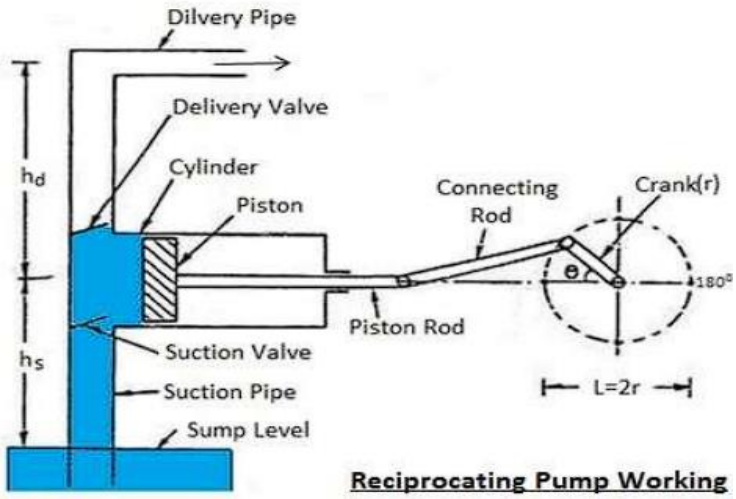
- **Reciprocating Pumps** are positive displacement machines typically **used for** low-flow, *high-pressure* operations.

- **Centrifugal pump** is a roto-dynamic **pump** that uses kinetic energy to transfer fluid from low pressure to high pressure while the **reciprocating pump** uses a piston (suction and discharge stroke) to transfer fluid.

# RECIPROCATING PUMP

The main components of R.P.:

1. Cylinder.
2. Piston and Piston Rod.
3. Crank and Connecting Rod.
4. Suction Pipe.
5. Suction Valve.
6. Delivery Pipe.
7. Delivery Valve.



Reciprocating Pump Working

**Water Sump:**
It is the source of water. From the sump, water is to be transported to the delivery pipes by the usage of the piston.

**Strainer:**
It acts as a mesh that can screen all the dirt, dust particles, etc. from the sump. If there is no strainer, then the dirt or dust also enters into the cylinder which can jam the region and affects the working of the pump.

**Suction Pipe:**
The main function of the suction pipe is to collect the water from the sump and send it to the cylinder via a suction valve. The suction pipe connects the water sump and the cylinder.

**Suction Valve:**
It is a non-return valve which means it can take the fluid from the suction pipe and send it to the cylinder but cannot reverse the water back to it. In the sense, the flow is unidirectional.
This valve opens only during the suction of fluid and closes when there is a discharge of fluid to outside.

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**Cylinder:**
It is a hollow cylinder made of cast iron or steel alloy and it consists of the arrangement of piston and piston rod.

**Piston and Piston rod:**
For suction, the piston moves back inside the cylinder and for discharging of fluid, the piston moves in the forward direction.
The Piston rod helps the piston to move in a linear direction i.e. either the forward or the backward directions.

**Crank and Connecting rod:**
For rotation, the crank is connected to the power source like engine, motor, etc. whereas the connecting rod acts as an intermediate between the crank and piston for the conversion of rotary motion into linear motion.

**Delivery Pipe:**
The function of the delivery pipe is to deliver the water to the desired location from the cylinder.

**Delivery valve:**
Similar to the suction valve, a delivery valve is also a Non-return valve. During suction, the delivery valve closes because the suction valve is in opening condition and during Discharge, the suction valve is closed and the delivery valve Is opened to transfer the fluid.
These are the various components of Reciprocating pump. Let's understand the working principle of it.

# TYPES OF RECIPROCATING PUMP

1. According to the water being in contact with one side or both sides of the piston-

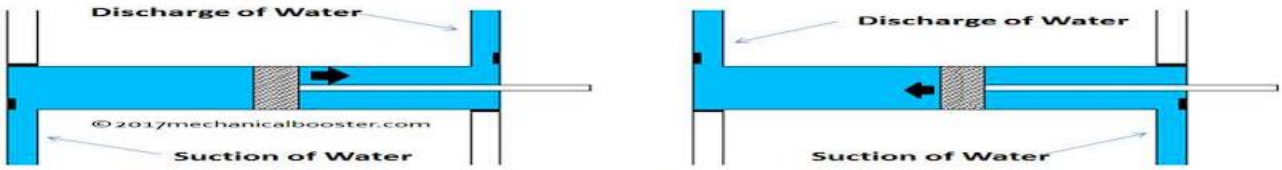
A. Single acting pump
B. Double acting pump

2. According to the number of cylinder provided

A. Single cylinder pump,
B. Double cylinder pump,
C. Triple cylinder pump.

# RECIPROCATING PUMP


Single Acting Reciprocating Pump




Double Acting Reciprocating Pump

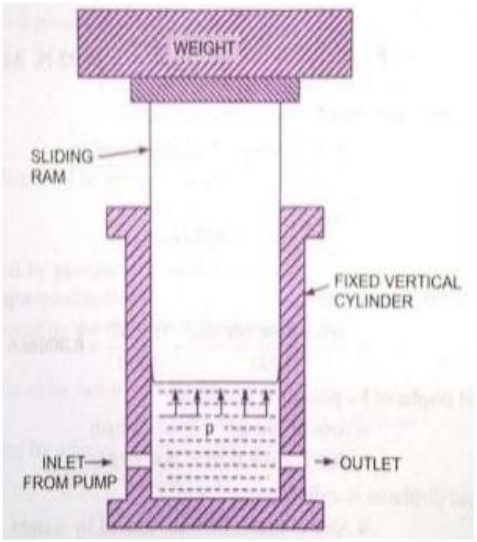
# HYDRAULIC ACCUMULATOR

❖ The hydraulic accumulator is a device used for storing energy of a liquid in the form of pressure energy, which may be supplied for any sudden or intermittent requirement.

❖ In hydraulic lift or the hydraulic crane, a large amount of energy is required when lift or crane is moved upward.

❖ This energy is supplied from hydraulic accumulator.

❖ When the lift is moving in the downward direction, no external energy is required at that time, the energy from the pump is stored in the accumulator.



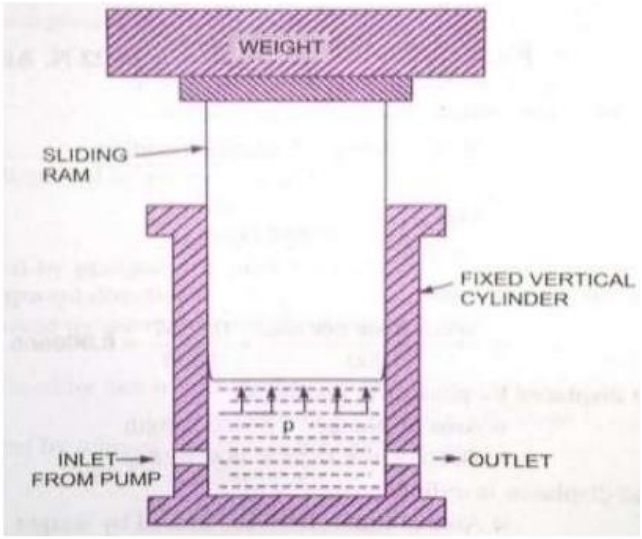
## CONSTRUCTION

❖ Hydraulic accumulator consists of a fixed vertical cylinder containing a sliding ram.

❖ The heavy weight is placed on the ram.

❖The inlet of the cylinder is connected to the pump which continuously supply water under pressure to the cylinder.

❖ Outlet of the cylinder is connected to the machine which may be a lift or a crane

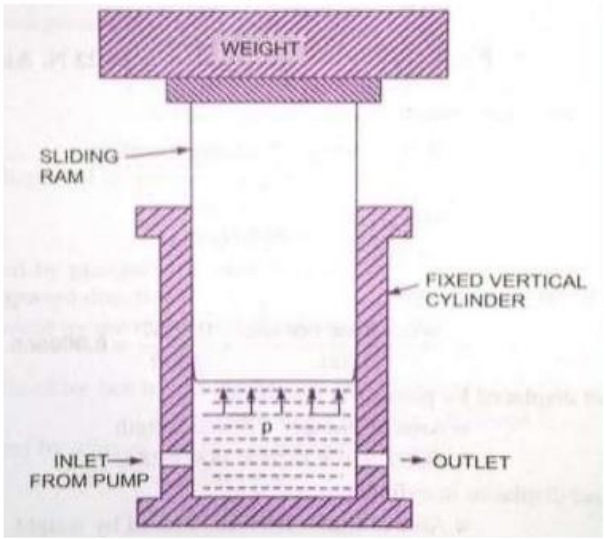



## WORKING

❖The ram is at the lower position in the beginning.

❖The pump supplies water under pressure continuously.

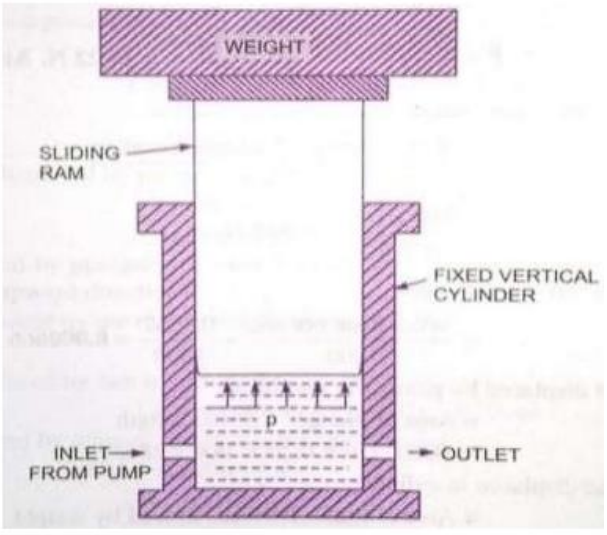
❖If the water under pressure is not required by the machine the water pressure will be stored in the cylinder.




❖This will raise the ram on which the heavy weight is placed.

❖When the ram is at the upper most position the cylinder is full of water and the accumulator as stored the maximum amount of pressure energy.

❖ When the machine requires large amount of energy the hydraulic accumulator will supply this energy and the ram will move in the downward direction.



## CAPACITY OF HYDRAULIC ACCUMULATOR

It is defined as the maximum amount of a hydraulic energy stored in a accumulator.

Let

A=Area of the sliding ram, L=stroke or lift of the ram

P=intensity of water pressure supplied by the pump,

W=weight placed on the ram,

W=intensity of pressure x area of ram

=(P x A)

The work done in lifting the ram=W x lift of the ram

=W x L

=P x L X A

Therefore the capacity of accumulator =work done in lifting the ram

=P x A x L

**Capacity of accumulator = P X Volume of accumulator**

= A x L=volume

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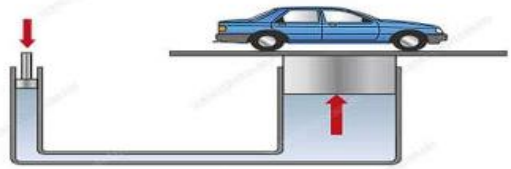
## HYDRAULIC LIFT

❖ Hydraulic lift is a device used for carrying passenger or goods from one floor to another in multistoried building to raise heavy objects.

❖ It works on the principle of Pascal's Law.



## TPPES OF HYDRAULIC LIFT

The Hydraulic Lifts are of two types-

1. Direct acting hydraulic lift
2. Suspended hydraulic lift

## 1. DIRECT ACTING HYDRAULIC LIFT

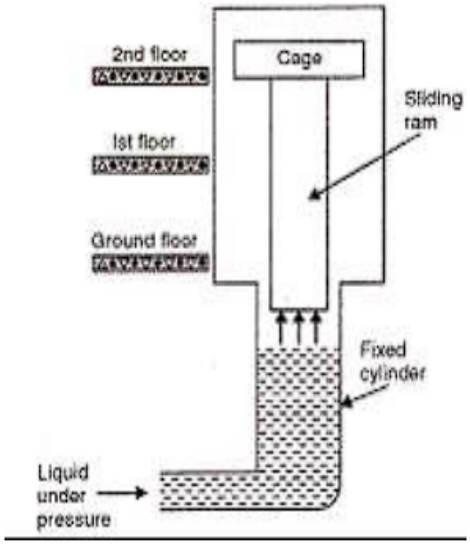
❖ It consists of a ram, sliding in the fixed cylinder.

❖At the top of the sliding ram a cage is fitted.

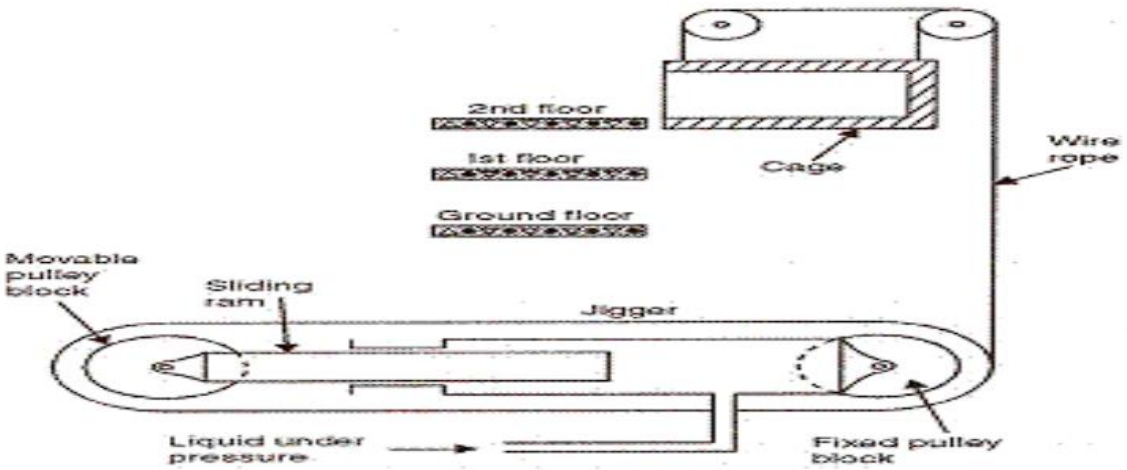
❖Cage- on which the person may be stand or goods may be placed.

❖The liquid under pressure flows into fixed cylinder.

❖This liquid exerts force on the sliding ram, which moves vertically up and thus raises the cage to the required height.




## 2. SUSPENDED HYDRAULIC LIFT




## 2. SUSPENDED HYDRAULIC LIFT

❖ When water under high pressure is admitted into the fixed cylinder of the jigger, the sliding ram is forced to move towards left.

❖As one of the end of the sliding ram is connected to the movable pulley block.

❖Hence the movable pulley block moves towards the left , thus increasing the distance between two pulley blocks.

❖The wire rope connected to cage is pulled and the cage is lifted.

❖For lowering the cage, water from fixed cylinder is taken out.

## 2. SUSPENDED HYDRAULIC LIFT

❖The sliding ram moves towards right and hence movable pulley block also moves towards right.

❖This decrease the distance between two pulley blocks and cage is lowered due to increased length of the rope

# BUDDHA SERIES

## (Unit Wise Solved Question & Answers)

## Course – B.Tech

## College – Buddha Institute of Technology

**(AKTU CODE-525)**

## Department: ASH 1

## Subject: Fundamental of Mechanical Engineering (BME101)

## Faculty Name: Mohd Faizan / S.B Lal

## Unit - 5

## Unit – V

## SYLLABUS

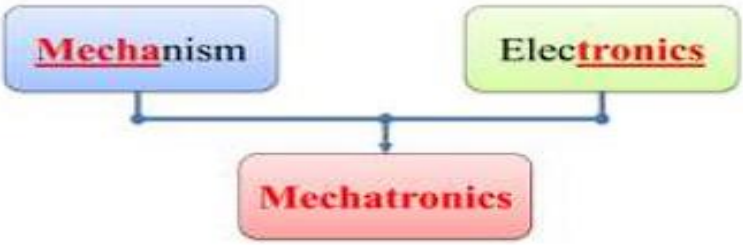
**Introduction**: Evolution, Scope, Advantages and disadvantages of Mechatronics, Industrial applications of Mechatronics, Introduction to autotronics, bionics, and avionics and their applications. Sensors and Transducers: Types of sensors, types of transducers and their characteristics.

Overview of Mechanical Actuation System – Kinematic Chains, Cam, Train Ratchet Mechanism, Gears and its type, Belt, Bearing Hydraulic and Pneumatic Actuation Systems: Overview:

Pressure Control Valves, Cylinders, Direction Control Valves, Rotary Actuators, Accumulators, Amplifiers, and Pneumatic Sequencing Problems

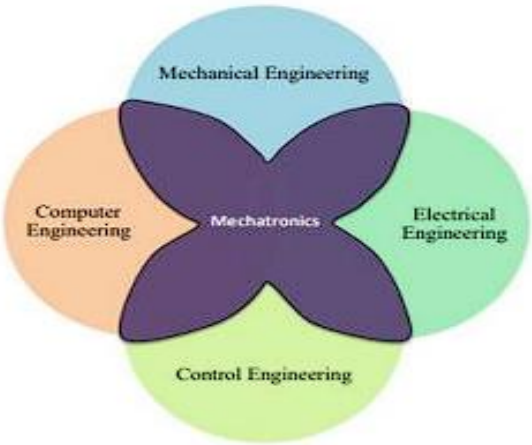
### Q.1 What is "Mechatronics"?

- Mechatronics is a concept of Japanese origin (1970's) and can be defined as the application of electronics and computer technology to control the motions of mechanical systems.




### Mechatronics.....

- It is a multidisciplinary approach to product and manufacturing system design (Figure).
- It involves application of electrical, mechanical, control and computer engineering to develop products, processes and systems with greater flexibility, ease in redesign and ability of reprogramming.
- It concurrently includes all these disciplines.



## Mechatronics.....

- Mechatronics can also be termed as replacement of mechanics with electronics or enhance mechanics with electronics.
- **For example, in modern automobiles, mechanical fuel injection systems are now replaced with electronic fuel injection systems.**
- This replacement made the automobiles more efficient and less pollutant.
- By employment of reprogrammable microcontrollers/microcomputers, it is now easy to add new functions and capabilities to a product or a system.
- **Today's domestic washing machines are "intelligent" and four-wheel passenger automobiles are equipped with safety installations such as air-bags, parking (proximity) sensors, antitheft electronic keys etc.**

## Q.2 What are the Advantages of Mechatronics?

1. Mechatronics enhances functionality and features.
2. It brings more efficiency.
3. Mechatronics adds intelligence to design of the system.
4. Mechatronics solutions are less expensive when compared to mechanical solutions.
5. A mechatronic solution improves design and reliability.
6. It is also more user-friendly and safer to use.
7. Mechatronic uses microcontroller, by which precision, position, speed, flow rate, and variables can be controlled.

## Q.3 What are the Dis-advantages of Mechatronics?

1. High initial cost of the system.
2. Imperative to have knowledge of different engineering field for design and implementation.
3. Specific problem for various system would have to be addressed separately and properly.
4. It is expensive to incorporate mechatronic approach to an existing/old system.
5. Maintenance and servicing are costly .

## Q.4 What are the Industrial application of Mechatronics?

- Mechatronics based automated systems such as automatic inspection and quality assurance, automatic packaging, record making, and automatic dispatch help to expedite the entire manufacturing operation.
- **It is widely used in aeronautics engineering** for unmanned aerial vehicles and automatic pilots. **In the defense industry it is used for automatically guided vehicles** and mine detection robots.

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## Q.5 Write short notes on Autotronics.

**Definition:** Autotronics can be defined as the **combination of automobile and electronics** or we can say that the **use of electronics science in automobile vehicles is called autotronics.**

**Major Areas:**

- The use of electronics in the automobile field makes the system safe, improved and efficient.
- At present, in the new generation automobiles almost 75%-85% of automobile parts are embedded with electronics system.
- The main areas of automobiles using autotronics are engine controlling system, airbags, antilock braking system, lightening interiors, GPS, music systems etc.
- In the autotronics systems the use of control units like sensors, motors and digital equipment establishes a communication between the various essential system and components of the vehicle.

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## Q.6 Write short notes on Bionics.

- **Bionics is a field of technology that combines the study of biology in nature and its patterns, with mechatronics, which combines mechanical, electronics and software.**
- Bionics consists of many different subject areas, but one of the most eye-catching and popular is bionic implants.
- **These implants aim to improve the standard of living for people who have damaged body parts such as arms, legs, eyes, or even ears.**

## Working of bionic implants

- It's extremely hard to mimic the actions created by regular limbs. It's something that software and hardware engineers have a lot of trouble working with.
- To solve this, all the successful bionics systems use machine learning to mimic physical movements.
- **Myoelectric** *(Myo = muscles)* sensors are used in bionic limbs to generate an electrical signal from muscle contractions.
- This is useful because it can get signals from the still functional nerve endings of the amputated limb. This means that the sensors can pick up when the user wants to move that area.
- In some cases, to improve the accuracy of myoelectric sensors, small incisions are made to place them closer to the muscle/nerve endings.

## Q.7 Write short notes on Avionics.

- **Avionics are the electronics systems used in aircraft, artificial satellite, and spacecraft. Avionic systems include communications, navigation, the display and management of multiple systems,** and the hundreds of systems that are fitted to aircraft to perform individual functions.
- Avionics grew in 1950's and 1960 as electronic devices which replaces the mechanical or analog equipment in the aircraft.
- Avionics equipment on a modern military or civil aircraft account for around;
  - 30% of the total cost of the aircraft
  - 40% in the case of a maritime patrol/antisubmarine aircraft or helicopter.
  - Over 75% of the total cost in the case of an airborne early warning aircraft (AWACS).

**NEED FOR AVIONICS:**

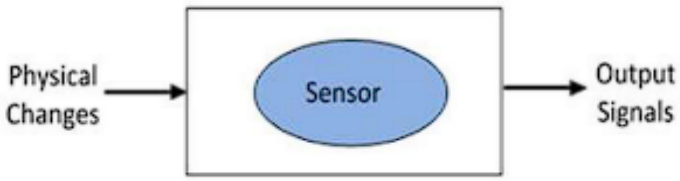
- To enable the flight crew to carry out the aircraft mission safely and efficiently. For civil airliner the mission is carrying passengers to their destination. For military aircraft the mission is intercepting a hostile aircraft, attacking a ground target, reconnaissance or maritime patrol.

**Advantages**

- Increased safety
- Air traffic control requirements
- All weather operation
- Reduction in fuel consumption
- Improved aircraft performance and control and handling and reduction in maintenance costs

## Q.8 Define Sensor with an example.

- **Sensor:** A sensor is a device that provides usable output in response to change in a specified physical quantity which is measured. A device that receives and responds to a signal .
- The physical quantity may be temperature, force, pressure, displacement, flow etc.
- **For example, the bulb of a thermometer** senses the temperature of the body in contact




Sensor

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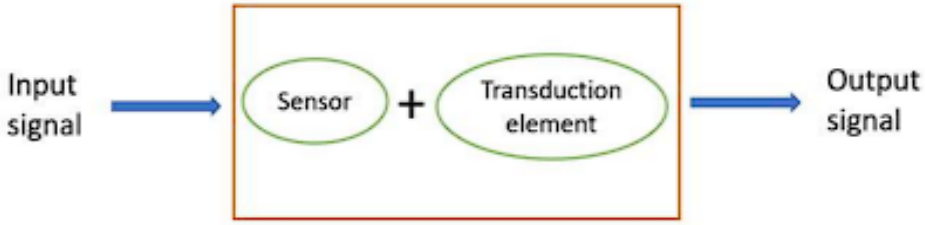
## Q.9 Define transducer with an example.

- The **transducer** is a device that changes the physical attributes of the non-electrical signal into an electrical signal which is easily measurable. The process of energy conversion in the transducer is known as the transduction(figure). It consists of two parts:

1. Sensing element/detector
2. Transduction element

**For example : thermometer**



## Q.10 List the types of sensors.

- Temperature Sensor
- Proximity Sensor
- Accelerometer
- IR Sensor (Infrared Sensor)
- Pressure Sensor
- Light Sensor
- Ultrasonic Sensor
- Smoke, Gas and Alcohol Sensor
- Touch Sensor, colour sensor
- Humidity Sensor
- Flow and Level Sensor

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## Q.11 List the types of transducers.

**Types of transducers:**

There are of many different types of transducer, they can be classified based on various criteria as:

1. **Transducer based on Quantity to be Measured**

- Temperature Transducers (e.g thermocouple)
- Pressure transducers (e.g. a diaphragm)
- Displacement transducers (e.g. LVDT)
- Oscillator transducers
- Flow transducers

2. **Transducer based on the Principle of Operation**

- Capacitive
- Inductive
- Resistive
- Photoelectric
- chemical

3. **Transducer based on need of an External Power Source**

- **Active Transducer:** Active transducers are those which do not require any power source for their operation. For example, a thermocouple, thermometer etc.
- **Passive Transducer:** Transducers which require an external power source for their operation is called as a passive transducer. For example, a strain gauge, thermistor etc.

## Q.12 Explain Characteristics of sensors and transducers

- The performance characteristics are mainly divided into two categories:

**i) Static characteristics ii) Dynamic characteristics**

### i. Static characteristics:

Static characteristics refer to the characteristics of the system when the input is either held constant or varying very slowly. Range, sensitivity, linearity, resolution, accuracy, precision, response time etc are important static characteristics.

### ii. Dynamic characteristics:

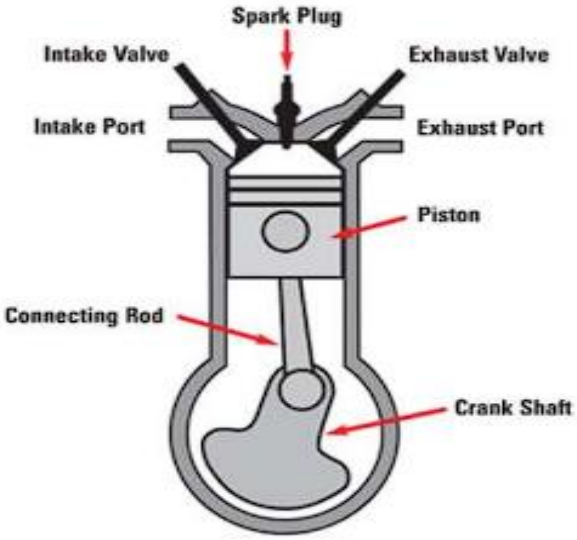
Dynamic characteristics refer to the performance of the instrument when the input variable is changing rapidly with time. For example, human eye cannot detect any event whose duration is more than one-tenth of a second; thus, the dynamic performance of human eye cannot be said to be very satisfactory. Few important dynamics characteristics are dynamic error, speed of response.



## Q.13 Define Kinematic Link or Element with an example.

### Kinematic Link or Element:

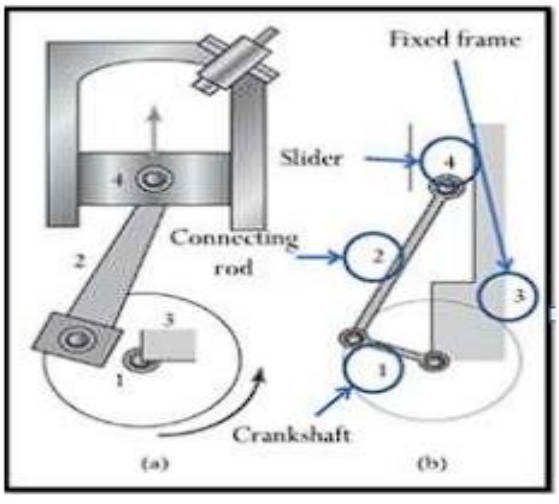
- Every part of a machine which is having some relative motion with respect to some other parts will be known as kinematic link or element.
- **Examples** : Piston, Connecting rod, crank, lever etc.



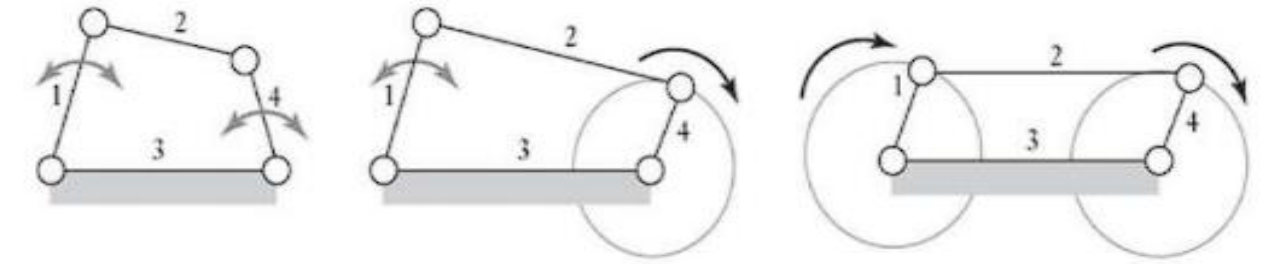

## Q.14 Define Kinematic chain with an example.

### Kinematic Chain:

- "If all the links are connected in such a way that **first link is connected to last link** in order to get the close chain and if all the relative motion in this close chain are constrained then such a chain is known as kinematic chain".



- **The Four-bar Chain**
  - Consists of 4 links connected to give 4 joints about which turning can occur.




Double-lever mechanism  Lever-crank mechanism  Double-crank mechanism

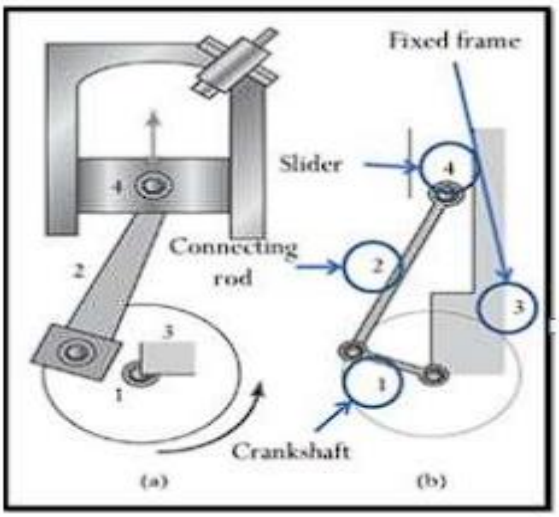
## Q.15 Define mechanism and machine.

**Mechanism:**

- "If one of the links of kinematic chain is fixed then it will be known as mechanism".

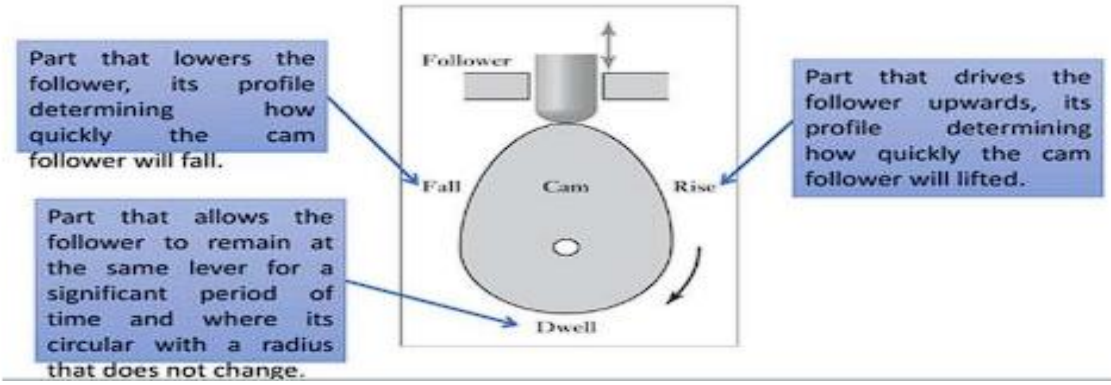
**Machine:**

- "When a mechanism is utilized in order to get desired output with respect to given input then it will be known as a machine".




## Q.16 Define CAM with diagram.

- Cam is a body which rotates or oscillates and in doing so imparts a reciprocating motion to a second body called follower, with which it is in contact.
- The length of times spent for the rotation is depending on the shape of the cam.

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## Q.17 What are the types of CAM ?.

### Types of Cams:

Cams can be classified according to

- Shape
- Follower movement
- Manner of constraint of the follower

1. Wedge and flat cams
2. Radial or disc cams
3. Spiral cams
4. Cylindrical cams
5. **Spherical cams**

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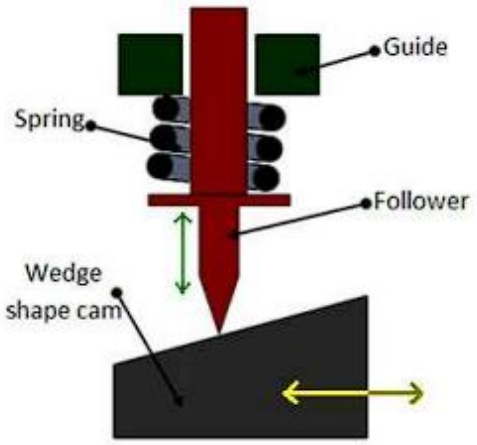
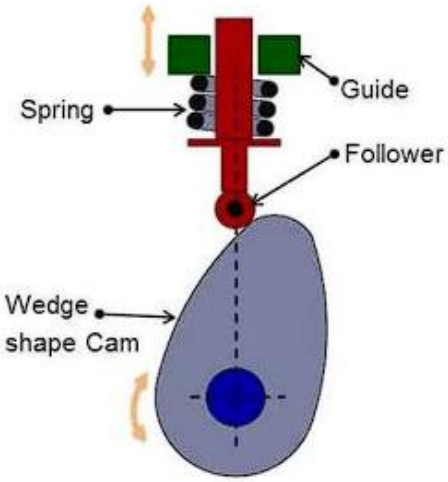
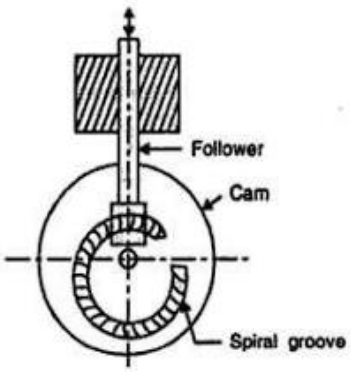
### 1. Wedge and flat cams



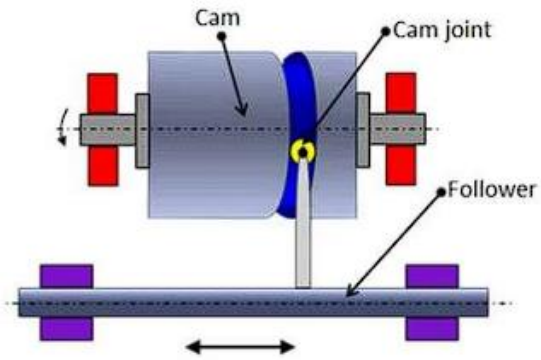

### 2. Radial or disc cams



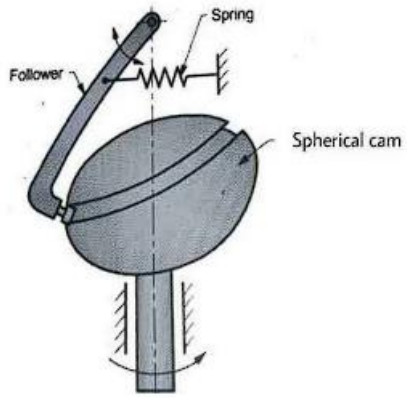

### 3. Spiral cams




### 4. Cylindrical cams



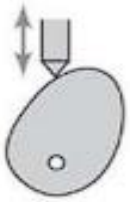
## 5. Spherical cams




## Q.18 What are the types of followers ?.

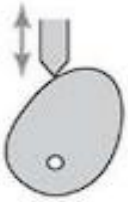
- Figure below shows a number of examples of different types of cam followers.

Point



(a)

Knife



(b)

Roller

(c)

Lower friction than sliding contact but can be more expensive

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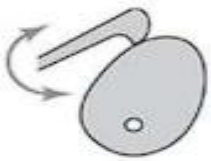
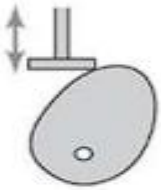
- Figure below shows a number of examples of different types of cam followers.

Sliding and oscillating



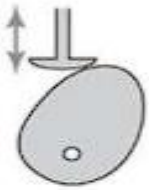
(d)

Flat



(e)

Mushroom



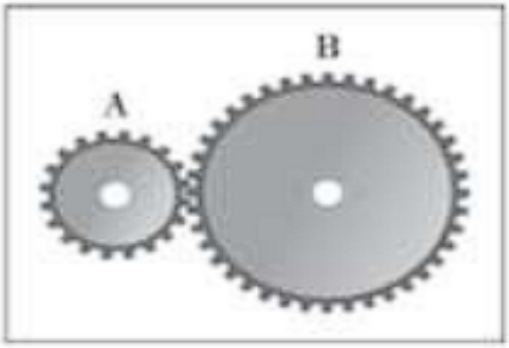
(f)

Often used because – cheaper and can be made smaller than roller follower.

## Q.19 What is the use of gears or gear drive ?

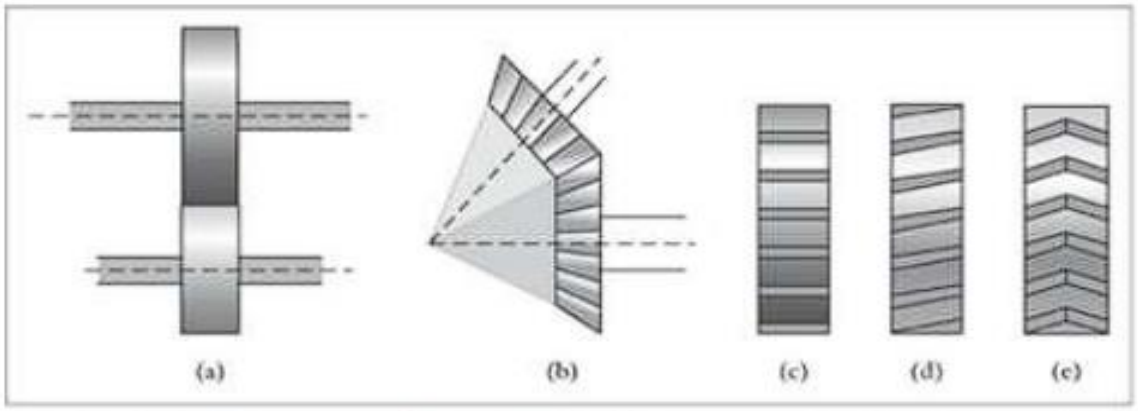
**Gears are used to**

- Transmit power
- Change the velocity
- Change the direction




**Gear Ratio:**

## Q.20 Explain the types of gears .




(a) Parallel gear axes, (b) axes inclined to one another, (c) axial teeth, (d) helical teeth, (e) double helical teeth

### Types of gears

**Spur gear :** This is Cylindrical gear. Teeth are parallel to axis. This is a highly demanded gear, which is easy to manufacture and to assemble.

**Helical gear :** This is a Cylindrical gear. Teeth have helix curve. Helical gear provides more strength, less oscillation and lower noise level compared with Spur gears.

**Internal gear :** This is a cylindrical gear ring with teeth formed at the inner diameter.

**Straight bevel (Miter) gear**: Miter gear has shaft angle of 90° and gear ratio of 1:1.

**Rack and pinion :** „A rack is a gear whose pitch diameter is infinite, resulting in a straight line pitch circle. Used to convert rotary motion to straight line.

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## Q.21 What do you mean by gear trains ?.

- ❖ The term gear train is defined as a series of intermeshed gear wheels.
- ➢ It is required when large distance is there between two gears.
- ➢ It is required when very high/very low velocity ratio is required.

- ❖ **Gear train may be simple gear train or may be compound gear train.**

Any Gear train is a combination of

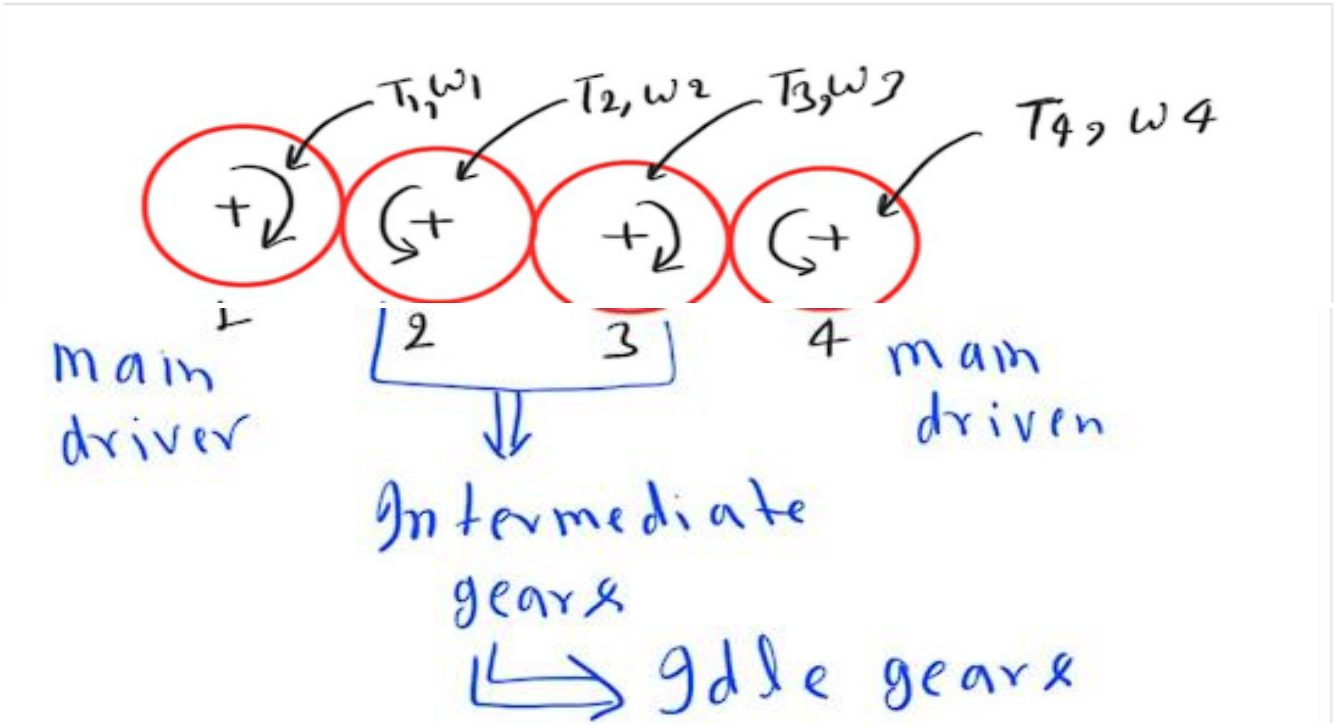
(I) Main DVR (driver)

(II) Main DVN (driven)

(III) Intermediate Gears

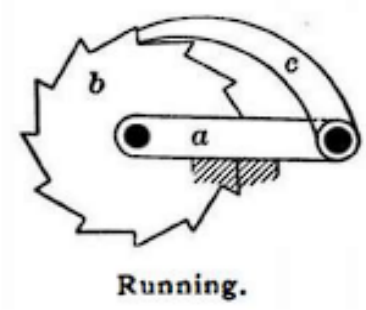
# Q.22 Explain Simple Gears Train.

- Every shaft is having only one gear as shown in the fig.
- For such a gear train, the overall gear ratio is the ratio of the angular velocities at the input and output shafts.

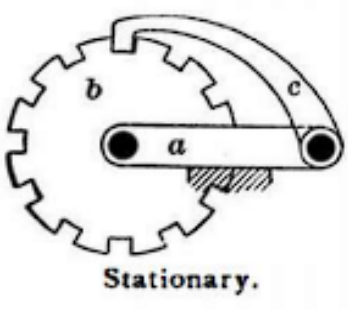



# Q.24 What do mean by Ratchet Mechanism

- In Ratchet Mechanism, gearing are arranged in such a way that certain links are temporarily or periodically locked together or connected during the action of the mechanism.
- This locking of relative motion may be so effected that relative motion of the two links is only possible in one sense or direction (when the gear is called by Reuleaux a Running-ratchet Train), or movement in both directions may be rendered impossible when the ratchet acts, in which case the gear is known as a Stationary-ratchet Train.



Running.



Stationary.

- Each consists of a frame or arm **a**, ratchet-wheel **b**, and ratchet or click **c.** In the first figure **b** is evidently capable of left-handed rotation only, so long as the ratchet **c** (sometimes called a pawl) is resting against its teeth.
- In the second figure motion is only possible when the pawl is lifted clear.

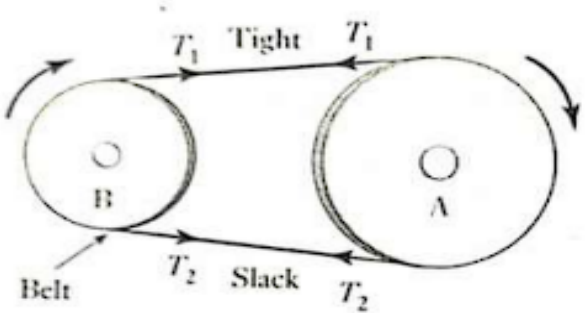
## Q.25 What is belt drive?

- Belt drives use the friction that develops between the pulleys attached to the shafts and the belt around the arc of contact in order to transmit a torque.
- The torque is due to the differences in tension that occur in the belt during operation.
- Let $T_1$ is the tension in the tight side and $T_2$ is the tension in slack side.

$$\text{torque on A} = (T_1 - T_2)r_A$$

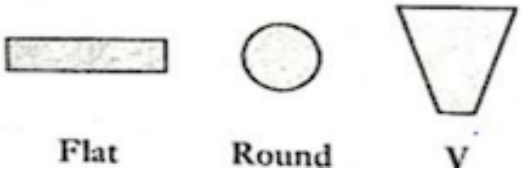
$$\text{torque on B} = (T_1 - T_2)r_B$$

$$\text{power} = (T_1 - T_2)v$$



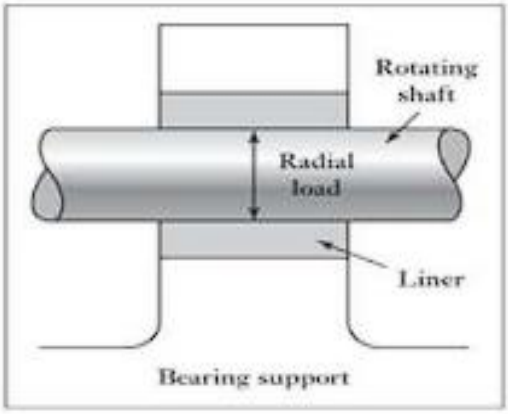

## Q.26 What are the various types of belts used for power transmission?

- **Flat :** The belt has a rectangular cross-section and produces less noise. They can transmit power over a long distance between pulley centers
- **Round :** The belt has a circular cross-section and used with grooved pulleys.
- **V :** V-belts are used with grooved pulleys and are less efficient than flat belts.

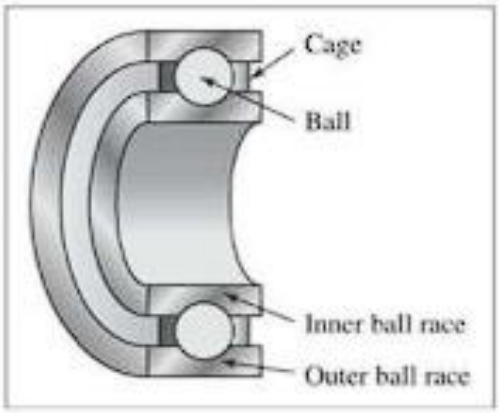


# Q.27 Write the definition of bearing and its classification.

- **Plain journal bearings**
  - Used to support rotating shafts which are loaded in a radial direction (journal – shaft).
  - Consists of an insert of some suitable material which is fitted between the shaft and the support.
  - Rotation of the shaft results in its surface sliding over that of the bearing surface.
  - The bearing may be a dry rubbing bearing or lubrication.




- **Ball and roller bearing**
  - With this type of bearing, the main load is transferred from the rotating shaft to its support by rolling contact rather than sliding contact.
  - A rolling element bearing consists of 4 main elements : an inner race, an outer race, the rolling element either balls or rollers, and a cage to keep the rolling elements apart.
  - The inner and outer races contain hardened tracks in which the rolling elements roll.

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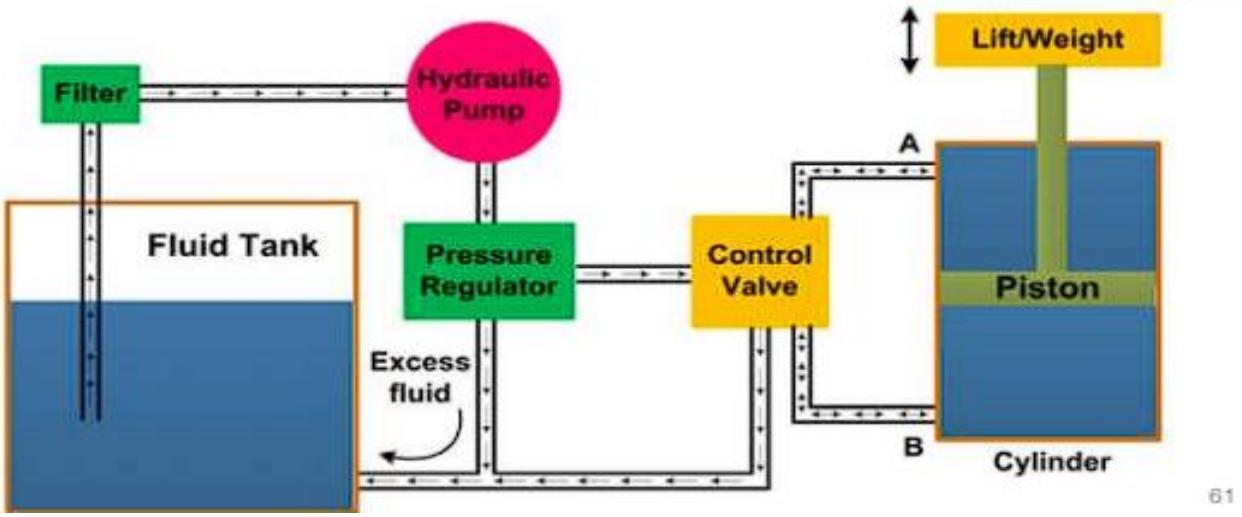
## Q.28 Explain Hydraulic system.

- The controlled movement of parts or a controlled application of force is a common requirement in the industries.
- These operations are performed mainly by using electrical machines or diesel, petrol and steam engines as a prime mover.
- These prime movers can provide various movements to the objects by using some mechanical attachments like screw jack, lever, rack and pinions etc.
- However, these are **not the only** prime movers. The enclosed fluids (**liquids and gases**) can also be used as prime movers to provide controlled motion and force to the objects or substances.

## Hydraulic system.....

- The specially designed enclosed fluid systems can provide both linear as well as rotary motion.
- The high magnitude controlled force can also be applied by using these systems.
- This kind of enclosed fluid based systems using pressurized incompressible liquids as transmission media are called as hydraulic systems.
- **The hydraulic system works on the principle of Pascal's law which says that the pressure in an enclosed fluid is uniform in all the directions.**

## Q.29 What are the Basic Components of Hydraulic System?



## Basic Components of Hydraulic System.....

The hydraulic systems consists a number of parts for its proper functioning. It consists of:

- a movable piston connected to the output shaft in an enclosed cylinder
- storage tank
- filter
- electric pump
- pressure regulator
- control valve
- leak proof closed loop piping.

## Q.30 What are the applications of hydraulic systems

The hydraulic systems are mainly used for precise control of larger forces. The main applications of hydraulic system can be classified in five categories:

**1. Industrial:** Plastic processing machineries, steel making and primary metal extraction applications, automated production lines, machine tool industries, paper industries, loaders, crushes, textile machineries, R & D equipment and robotic systems etc.

**2. Mobile hydraulics:** Tractors, irrigation system, earthmoving equipment, material handling equipment, commercial vehicles, tunnel boring equipment, rail equipment, building and construction machineries and drilling rigs etc. 63

**3. Automobiles:** It is used in the systems like breaks, shock absorbers, steering system, wind shield, lift and cleaning etc.

**4. Marine applications:** It mostly covers ocean going vessels, fishing boats and navel equipment.

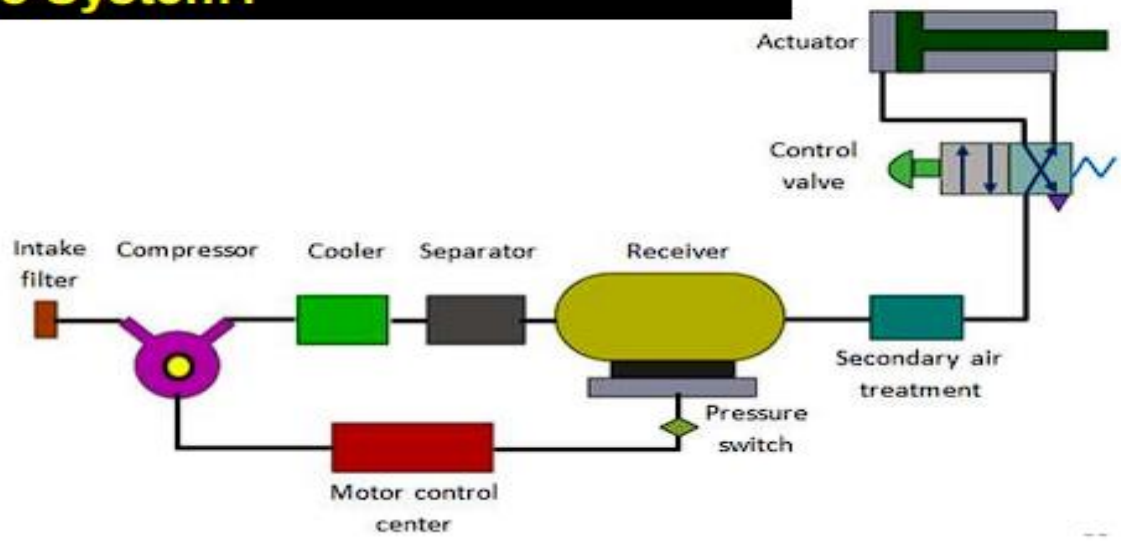
**5. Aerospace equipment:** There are equipment and systems used for rudder control, landing gear, breaks, flight control and transmission etc. which are used in airplanes, rockets and spaceships.

## Q.31 Explain Pneumatic system.

- Pneumatic technology deals with the study of behavior and applications of **compressed air** in our daily life in general and manufacturing automation in particular.

- Pneumatic systems use **air** as the medium which is abundantly available and can be exhausted into the atmosphere after completion of the assigned task.

## Q.32 What are the Basic Components of Pneumatic System?




**Important components of a pneumatic system are shown in fig**.

**a) Air filters:** These are used to filter out the contaminants from the air.

**b) Compressor:** Compressed air is generated by using air compressors. Air compressors are either diesel or electrically operated. Based on the requirement of compressed air, suitable capacity compressors may be used.

**c) Air cooler:** During compression operation, air temperature increases. Therefore coolers are used to reduce the temperature of the compressed air.

**d) Dryer:** The water vapor or moisture in the air is separated from the air by using a dryer.

**e) Control Valves:** Control valves are used to regulate, control and monitor for control of direction flow, pressure etc.

**f) Air Actuator:** Air cylinders and motors are used to obtain the required movements of mechanical elements of pneumatic system.

**g) Electric Motor:** Transforms electrical energy into mechanical energy. It is used to drive the compressor.

**h) Receiver tank:** The compressed air coming from the compressor is stored in the air receiver

## Q.33 What do you mean by Valves in hydraulic and pneumatic systems.

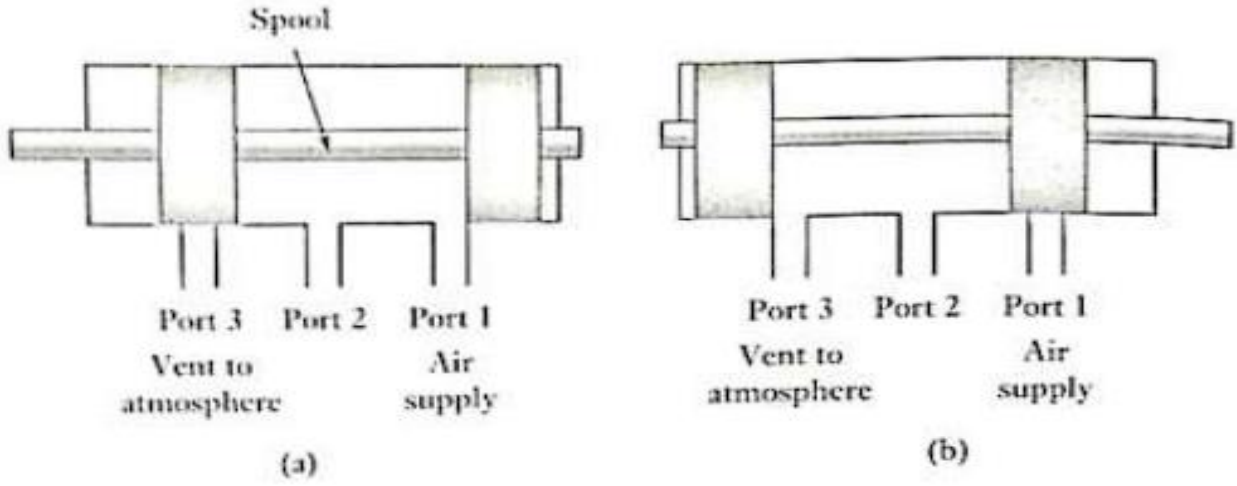
- Valves are used with hydraulic and pneumatic systems to direct and regulate to fluid flow.

1. Direction Control Valves
2. Pressure Control Valves

## Q.34 What do you mean by Direction Control Valves?

- Pneumatic and hydraulic systems use directional control Valves to direct the flow of fluid through a system.
- They do not vary the rate of fluid flow but either completely open or completely closed i.e. ON/OFF devices.
- They might be activated to switch the fluid flow direction by means of mechanical, electrical or fluid pressure signals.
- A common type of directional control valve is the spool valve.

# Spool Direction Control Valves




# Spool Direction Control Valves.....

- A spool moves horizontally within the valve body to control the flow.
- In fig (a) the air supply is connected to port 1 and port 3 is closed.
- Thus the device connected to port 2 can be pressurized.
- When the spool is moved to the left ( in fig b) the air supply is cut off and port 2 is connected to port 3.
- Port 3 is a vent to the atmosphere and so the air pressure in the system attached to port 2 is vented.
- Thus the movement of the spool has the air firstly to flow into the system and then be reversed and flow out of the system.

## Q.35 What do you mean by Pressure Control Valves?

- These are used to control the pressure in hydraulic and pneumatic system
- There are three main types of pressure control valves

.

a) Pressure regulating valves

b) Pressure – limiting/relief valves

c) Pressure sequence valves

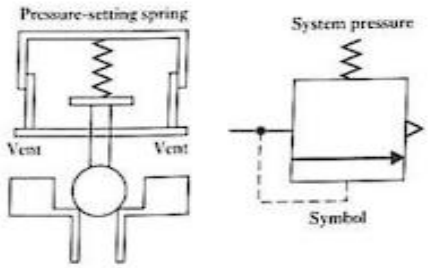
## a) Pressure regulating valves

- These are used to control the operating pressure in a circuit and maintain it at a constant value.

## b) Pressure – limiting/relief valves

- These are used as safety devices to limit the pressure in a circuit to below some safe value.
- The valve opens and vents to the atmosphere, or back to the sump, if the pressure rises above the safe value.
- It has one orifice which is normally closed.

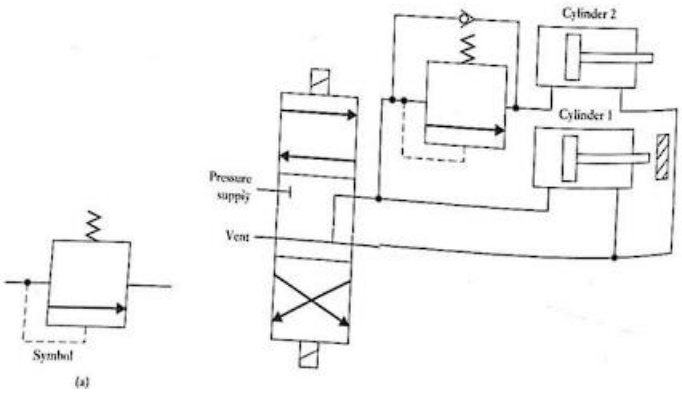
- When the inlet pressure overcomes the force exerted by the spring, the valve opens and vents to the atmosphere, or back to the sump.




## c) Pressure sequence valves

- These are used to sense the pressure of an external line and give a signal when it reaches some pre-set value.
- With the pressure limiting valve, the limiting pressure is set by the pressure at the inlet to the valve.
- We can adapt such a valve to give a sequence valve.
- This can be used to allow to flow occur to some part of the system when the pressure has risen to the required level.
- For example in an automatic machine we might require some operation to start when the clamping pressure applied to a work piece is at some particular value.

## Pressure sequence valves



# Q.36 Define Actuators.

- Actuators are output devices which convert energy from pressurized **hydraulic oil** or **compressed air** into the required type of action or motion.
- In general, hydraulic or pneumatic systems are used for gripping and/or moving operations in industry. These operations are carried out by using actuators.

- In general actuators can be classified into two types.

1. Linear actuators: These devices convert hydraulic/pneumatic energy into linear motion.**(Ex-cylinder)**

2. Rotary actuators: These devices convert hydraulic/pneumatic energy into rotary motion. **(Ex-Gear motor)**

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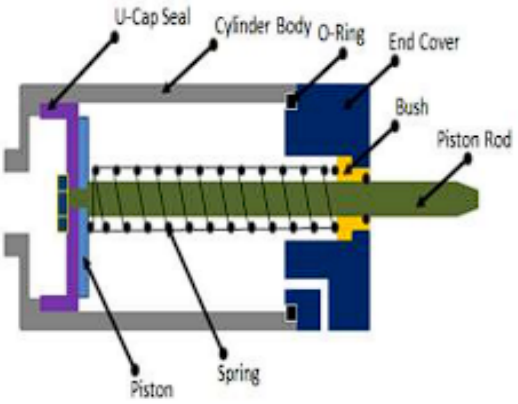
The construction of hydraulic and pneumatic linear actuators is similar.

However they differ at their operating pressure ranges.

**Typical pressure of hydraulic cylinders is about 100 bar and of pneumatic system is around 10 bar.**

# Q.37 Explain working single acting cylinder.

- These cylinders produce work in one direction of motion hence they are named as single acting cylinders.
- Figure shows the construction of a single acting cylinder.
- The compressed air pushes the piston located in the cylindrical barrel causing the desired motion.
- The return stroke takes place by the action of a spring.
- Generally the spring is provided on the rod side of the cylinder.

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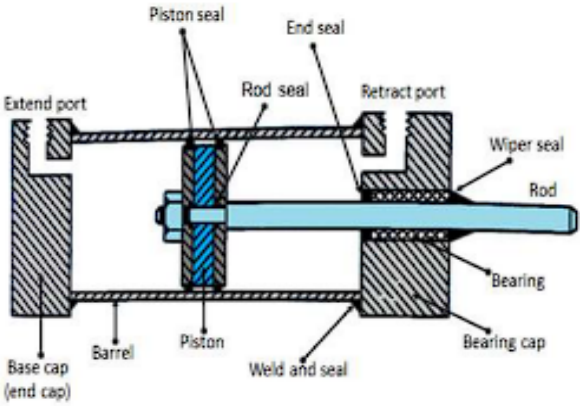
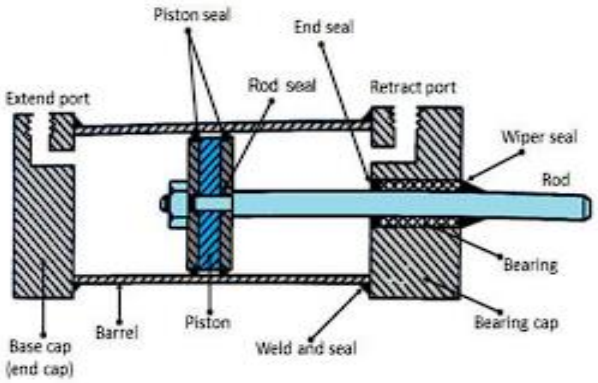
## Q.38 Explain working double acting cylinder.

- The main parts of a hydraulic double acting cylinder are: piston, piston rod, cylinder tube, and end caps.
- As shown in the fig. the piston rod is connected to piston head and the other end extends out of the cylinder.
- The piston divides the cylinder into two chambers.
- The seals prevent the leakage of oil between these two chambers.
- The cylindrical tube is fitted with end caps. .



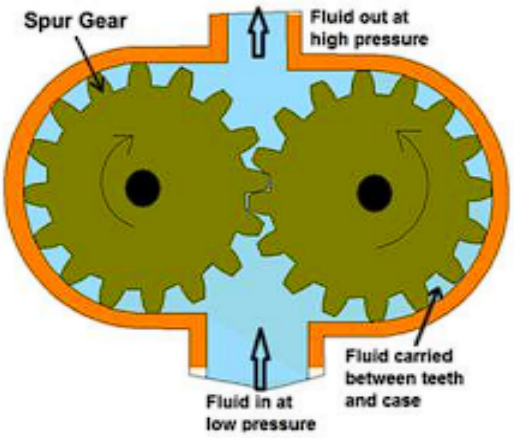

## Double acting cylinder.....

- The pressurized oil, air enters the cylinder chamber through the ports provided.
- In the rod end cover plate, a wiper seal is provided to prevent the leakage of oil and entry of the contaminants into the cylinder.
- The piston seal prevents metal to metal contact and wear of piston head and the tube. These seals are replaceable.
- End cushioning is also provided to prevent the impact with end caps.




## Q.39 Explain rotary Rotary Actuators.

- Rotary actuators convert energy of pressurized fluid into rotary motion. Rotary actuators are similar to electric motors but are run on hydraulic or pneumatic power.
- It consists of two inter meshing gears inside a housing with one gear attached to the drive shaft.
- Figure shows a schematic diagram of Gear motor.
- The air enters from the inlet, causes the rotation of the meshing gear due to difference in the pressure and produces the torque.
- The air exits from the exhaust port.
- Gear motors tend to leak at low speed, hence are generally used for medium speed applications.

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