ELEMENTS OF HYDRAULICS

Fluid → Properties ⟷
- Density
- Specific volume
- Specific weight
- Specific gravity
- Viscosity
- Cohesion
- Adhusion
- Surface tension
- Capillarity

$$\rho = \frac{m}{V} = \frac{Kg}{m^3}$$

$$1\,Kg/m^3 = \frac{1000\,gm}{10^6\,cm^3} = \frac{10^3\,gm}{10^6\,cm^3} = \frac{1}{10^3}\frac{gm}{cm^3} = 10^{-3}\,gm/cm^3$$

$$1000\,Kg/m^3 = \_\_\_\_\_\,gm/cm^3$$

$$1\,Kg/m^3 = 10^{-3}\,gm/cm^3$$

$$10^3\,Kg/m^3 = 10^3 \times 10^{-3}\,gm/cm^3 = 1\,gm/cm^3$$

Density or mass density

It defined as the ratio of the mass of the fluid to it's Volume.
It's unit is (Kg/m^3) or (gm/cm^3) → C.G.S unit.
→ It denoted by the symbol 'ρ'.

→ $\rho = \frac{\text{mass of the fluid}}{\text{Volume of the fluid}}$

→ The density of water is $1000\,Kg/m^3$ or $1\,gm/cm^3$.

Specific Volume ($\forall$)

→ It defined as the Volume of the fluid occupied by unit mass.

→ Specific Volume $= \frac{\text{Volume}}{\text{mass}}$

Q. The mass of a fluid is 6 Kg & it occupies a volume of $8m^3$. Determine it's density.

Ans. $$\rho = \frac{\text{mass of fluid}}{\text{Volume of the liquid}}$$

$$= \frac{6\,Kg}{8m^3}$$

$$= 0.75\ Kg/m^3$$

Q. Determine it's sp. weight ? (related in Q→1)

Ans. $$w = \rho \times g$$
$$= 0.75 \times 9.81\ N/m^3$$
$$= 7.3575\ N/m^3$$

Q. Determine the sp. gravity of that fluid ? (Q→1)

Ans. $$\frac{\text{weight density of liquid}}{\text{weight density of standard fluid}}$$

$$= \frac{0.75}{1000} = 0.00075$$

Q. Determine the sp. volume ? (Q→1)

Ans. $$\rho = \frac{1}{0.75} = \frac{1}{\frac{75}{100}} = \frac{100}{75} = 1.33\ m^3/Kg$$

Viscosity

It is the property of fluid which gives resistance when one lair of fluid is flowing over another adjasent lair of fluid.

→ The shearstress is proportional to the rate of change of velocity with respect to y. (Y = Distance)

Mathematically,

$$\tau \propto \frac{du}{dy}$$

$$= \frac{V}{m} = \frac{1}{\left(\frac{m}{V}\right)} = \frac{1}{\rho}$$

→ It's unit is m^3/Kg.

Sp. weight or weight density

→ It is the ratio between the weight of the fluid to it's volume.

$$w = \frac{W}{V} = \frac{mg}{V} = \left(\frac{m}{V}\right) g = \rho g = 1000 \times 9.81 \frac{N}{m^3}$$

→ Unit is N/m^3

Q. Write the relationship between sp. weight or weight density and density.

Ans. $w = \rho g$

where, w = sp. weight

ρ = Density

g = Acceleration due to gravity

Specific gravity

→ It defined as the ratio of the weight density or density of a fluid to the weight density of standard fluid.

→ It is also known as relative density.

→ It is dimension less quantity & denoted by the term 'S'.

$$S(\text{Liquid}) = \frac{\text{weight density of liquid}}{\text{weight density of standard fluid}}$$

$$= \frac{(\rho g)\ \text{liquid}}{(\rho g)\ \text{water}}$$

$$= \frac{(\rho)\ \text{liquid}}{(\rho)\ \text{water}} \times \frac{g}{g}$$

where, τ = Shear stress
du = Velocity
dy = Distance

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

where, μ is known as constant of proportionality and also we can called co-efficient of dynamic viscosity or only viscosity.

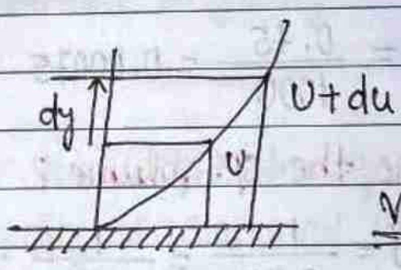
$\left(\frac{du}{dy}\right) \rightarrow$ Rate of shear stress

or

velocity gradient

or

Rate of shear deformation



Velocity Profile

$$\mu = \frac{\tau}{\left(\frac{du}{dy}\right)}$$

$$= \frac{\text{Shear Stress}}{\frac{\text{Change in velocity}}{\text{Change in distance}}}$$

$$= \frac{\text{Force}}{\text{Area}} \Big/ \left(\frac{\text{length}}{\text{Time}} \Big/ \text{length}\right)$$

$$= \frac{\text{Force}}{\text{Area}} \Big/ \frac{\cancel{\text{length}}}{\text{time}} \times \frac{1}{\cancel{\text{length}}}$$

$$= \frac{\text{Force}}{\text{Area}} \times \text{Time}$$

$$= \frac{\text{Force}}{(\text{length})^2} \times \text{Time}$$

* Force
- MKS → Kgf
- CGS → Dyne
- SI → Newton.

M.K.S system

$$\text{viscosity} = \frac{\text{Kgf} \times \text{Sec}}{m^2}$$

Similarly, in C.G.S system,

$$\left.\text{viscosity} = \frac{\text{Dyne} \times \text{sec}}{cm^2}\right\} \rightarrow \text{Poise}$$

S.I system

$$\text{viscosity} = \frac{N \times \text{sec}}{m^2}$$

Q. **Conversion of Unit of viscosity from M.K.S to C.G.S Unit**

5 mark

$$\text{viscosity} = \frac{1\ \text{Kgf} \times \text{Sec}}{m^2} = \frac{9.81\ N \times \text{sec}}{m^2}$$

$$= \frac{9.81 \times 1\ \text{Kg} \times \frac{1\ m}{\text{sec}^2} \cdot \text{sec}}{m^2}$$

$$= \frac{\frac{9.81 \times 10^{3}\, gm \times 10^{2}\, cm}{sec^{2}} \times sec}{m^{2}}$$

$$= \frac{\frac{9.81 \times 10^{5}\, gm \cdot cm}{sec^{2}} \times sec}{m^{2}} \quad \left\{ 1\, dyne = \frac{gm \cdot cm}{sec^{2}} \right\}$$

$$= \frac{9.81 \times \cancel{10^{5}}^{10}\, dyne \times sec}{\cancel{10^{4}}\, cm^{2}}$$

$$= \frac{9.81 \times 10\, dyne \times sec}{cm^{2}}$$

$$= 9.81 \times 10 \times \frac{dyne \times sec}{cm^{2}}$$

$$= 98.1\ Poise$$

$$9.81\ \frac{N\,sec}{m^{2}} = 98.1\ Poise$$

$$1\ \frac{N \cdot sec}{m^{2}} = \frac{98.1}{9.81} = 10\ Poise$$

$$\boxed{\frac{1}{10}\ \frac{N\text{-}sec}{m^{2}} = 1\ Poise}$$

$$1\ centipoise = \frac{1}{100}\ Poise$$

Semester

Q. Define viscosity

Q. Write the unit of viscosity

Q. convert C.G.S unit of viscosity to S.I unit.

Kinematic Viscosity (ν)

It is the ratio between dynamic viscosity and density of Fluid.

$$\nu = \frac{\text{Dynamic viscosity}}{\text{Density}}$$

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

$$\nu = \frac{\text{Force} \times \text{time}}{(\text{length})^2 \times \frac{\text{mass}}{\text{length}}}$$

$$= \frac{\text{force} \times \text{time}}{\left(\frac{\text{Mass}}{\text{length}}\right)}$$

$$= \text{Force} \times \text{time} \times \frac{\text{length}}{\text{mass}}$$

$$= \cancel{\text{mass}} \times \frac{\text{length}}{(\text{Time})^2} \times \cancel{\text{Time}} \times \frac{\text{length}}{\cancel{\text{mass}}}$$

$$= \frac{(\text{length})^2}{\text{Time}}$$

$$\text{M.K.S \& SI} = \frac{m^2}{sec}$$

$$\text{C.G.S} = \frac{cm^2}{sec}$$

$$1 \text{ stoke} = \frac{1 cm^2}{sec} = 10^{-4} \frac{m^2}{sec}$$

$$1 cs = \frac{1}{100} \text{ stoke}$$

lain is directly Proportional to the rate of shear ...

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

The fluid which obey the above relation is known Newtonian fluid.

Ex: water, K.oil, air etc.

→ The fluid which does n't obey the above the rel^n is as non-newtonian fluid.

Ex: Mud-flow, slurry, Blood, Polymer s...

Ideal fluid

The fluid which is incompresible & is having no vis... s known as ideal fluid.

...eal fluid

→ A fluid which Posseses viscosity is known as Real flu...

→ The viscosity of liquid decreases with increase in ... iscosity of gases increases with the increase of temp.

The velocity distribution for flow over a flat plate is ... $= \frac{3}{2}y - y^{3/2}$. where u = point velocity in m/s, at a di... meter above the plate. Determine the shear stress ... assumed dynamic viscosity is 8 Poise

Ans. Given data,

$$U = \frac{3}{2}y - y^{3/2}$$

$\mu = 8$ Poise ... Ns

Then,
$$\tau = \mu \cdot \frac{du}{dy}$$

$$\Rightarrow u = \frac{3}{2} y - y^{3/2}$$

$$\Rightarrow \left.\frac{du}{dy}\right]_{9m} = \frac{3}{2} - \frac{3}{2} y^{1/2}$$

$$\Rightarrow \frac{du}{dy} = \frac{3}{2} - \frac{3}{2} 9^{1/2}$$

$$= \frac{3}{2} - \frac{3}{2} \times 3$$

$$= \frac{3}{2} - \frac{9}{2}$$

$$= 1.5 - 4.5$$

$$= -3 \, s^{-1}$$

$$\left[\frac{\frac{m}{s}}{m} = \frac{\cancel{m}}{s} \times \frac{1}{\cancel{m}} = \frac{1}{s} = s^{-1} \right]$$

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

$$\Rightarrow \tau = 0.8 \times (-3) = -2.4 \, \frac{N}{m^2}$$

Q. A plate, 0.025 mm distance from a Fix plane moves are 50 cm per second and required a force of 1.471 N/m² to maintain the speed. Determine the fluid viscosity between the plate in Poise

Ans. Given data,

$$dy = y - 0 = 0.025 \text{ mm} = 0.025 \times 10^{-3} \text{ m}$$

$$du = U - 0 = U = 50 \text{ cm/sec} = 50 \times 10^{-2} \text{ m/s} = 0.5 \text{ m/sec}$$

Then, $\tau = 1.471 \, \frac{N}{m^2}$

$\mu = ?$ (in poise)

So, $\tau = \mu \cdot \frac{du}{dy}$

$$\Rightarrow 1.471 = \mu \times \left(\frac{0.5}{0.025 \times 10^{-3}} \right)$$

$$\Rightarrow \mu = \frac{1.471}{\frac{0.5}{0.025 \times 10^{-3}}}$$

$$\Rightarrow \mu = \frac{1.471 \times 0.025 \times 10^{-3}}{0.5}$$

$$\Rightarrow \mu = \frac{1.471}{20000}$$

$$\Rightarrow \mu = 0.00007355 \ \frac{Ns}{m^2}$$

$$= 0.0007355 \text{ Poise}$$

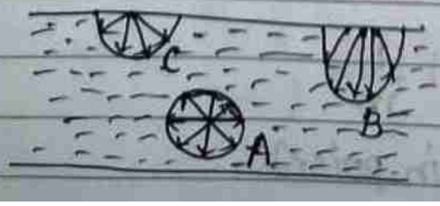
Cohesion

It means inter-molecular attraction between molecules of the same liquid. It enables to liquid to regist small amount of tensile stress.

Adhesion

It means attraction between the molecules of a liquid or molecules of a solid boundary surface is contact with the liquid. This proporty enables a liquid to steak to another body.

Surface Tension (σ)



$$So,\ \tau = \mu \cdot \frac{du}{dy}$$

$$\Rightarrow 1.471 = \mu \times \left(\frac{0.5}{0.025 \times 10^{-3}}\right)$$

$$\Rightarrow \mu = \frac{1.471}{\frac{0.5}{0.025 \times 10^{-3}}}$$

$$\Rightarrow \mu = \frac{1.471 \times 0.025 \times 10^{-3}}{0.5}$$

$$\Rightarrow \mu = \frac{1.471}{20000}$$

$$\Rightarrow \mu = 0.00007355\ \frac{Ns}{m^2}$$

$$= 0.0007355\ \text{Poise}$$

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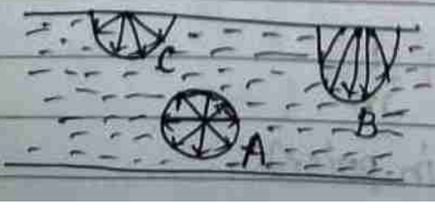


It is defined as the tensile force acting the surface of a liquid in contact with a gas two immiscible liquids such that the contact surface behave like a membrance under tension.

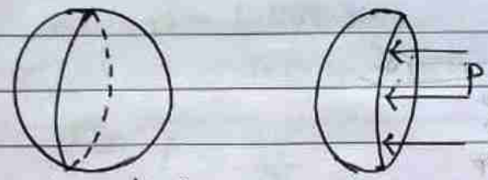
→ Magnitude of this force for unit length of the free surface will have the same value as the surface energy per unit area.

$$M.K.S \rightarrow Kgf/m$$

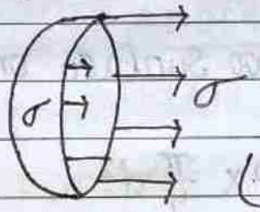
$$S.I \rightarrow N/m$$

Ex: Raindrops, Break-up of liquid jet

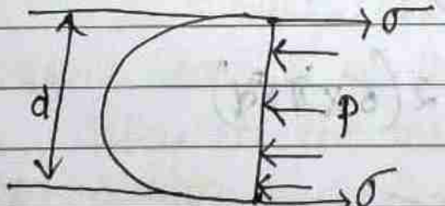
Pressure inside a water droplet



(water droplet) (Pressure force)



(surface Tension)



(F.B.D)

Pressure force $\Rightarrow F = P \times A = P \times \frac{\pi}{4} d^2$ — ①

Surface tension force acting around the circumference

$$\sigma \times \pi d \text{ — ②}$$

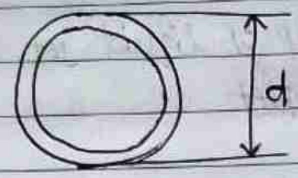
Under equillibrium condition these two forces will be equal and opposite.

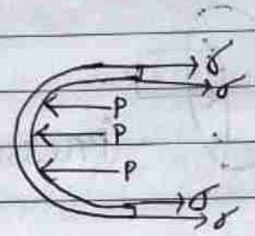
$$P \times \frac{\pi}{4} d^2 = \sigma \times \pi \times d$$

$$\Rightarrow \frac{Pd}{4} = \sigma$$

$$\Rightarrow P = \frac{4\sigma}{d}$$

Soap bubble





Soap bubbles have two surface on which surface tension sigma act

$$F = P \times A = P \times \frac{\pi}{4} d^2$$

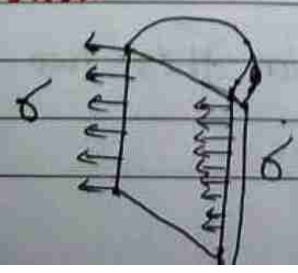
$$\Rightarrow 2(\sigma \times \pi d)$$

$$\Rightarrow P \times \frac{\pi}{4} d^2 = 2(\sigma \times \pi \times d)$$

$$\Rightarrow \frac{Pd}{4} = 2\sigma$$

$$\Rightarrow P = \frac{8\sigma}{d}$$

Liquid Jet



Pressure Force = P×A

= P×L×d

Surface tension = $\sigma L + \sigma L = 2\sigma L$

$P \times L \times d = 2\sigma L$

$\Rightarrow \boxed{P = \frac{2\sigma}{d}}$

Q. If the surface tension at air water interface is 0.069 N/m. What is the pressure difference between inside & outside of air bubble of diameter 0.009 mm.

Ans. Given data,

$\sigma = 0.069$ N/m

$d = 0.009$ mm

$= 0.009 \times 10^{-3}$ m

Then, $P = \frac{4\sigma}{d}$

$= \frac{4 \times 0.069}{0.009 \times 10^{-3}}$

$= \frac{0.276}{0.000009}$

$= 30666.666$ N/m²

Q. If the surface tension at the air soap interface is 0.09 N/m. Calculate the internal pressure in a soap bubble 28 mm diar.

Ans. Given data,

$\sigma = 0.09$ N/m

$d = 28$ mm

$= 28 \times 10^{-3}$

Then, $P = \frac{8\sigma}{d}$

$= \frac{8 \times 0.09}{28 \times 10^{-3}} = \frac{0.72}{0.028} = 25.714$ N/m²

Capillarity :-

It is defined as a Phenomenon of rise or fall of liquid surface in a Small of tube relative to the adjacent general level of liquid when the tube is held vertically in the liquid.

or,

Capillarity is a phenomenon by which a liquid rises into a thin glass tube above or below its general leve. This phenomenon is due to the combined effect of cohesion and adhesion of liquid Particle.

The rise of liquid surface is Known as capillarity.

Fall of liquid Surface Known as capillary fall.

Vapour pressure :-

A change from the liquid state to the gaseous state is Known as vaporization. The vaporization occurs because of continuous escaping of the molecule through the free liquid Surface.

→ when vaporization takes place, the molecule escapes from the surface of the liquid. These Vapour molecule get accumlated in the space between the free liquid surface and top of the vessel. These accumlated vapour exert a pressure on the liquid surface is Known as vapour pressure.

or,

This is the Process at which the liquid is converted into vapours.

Pascal's law

The intensity of Pressure at any Point in a liquid at rest, is the same in all direction.

Absolute and Gauge Pressure :-

The Pressure on a fluid is measured in two different systems.

In one system, it is measured above the absolute Presence in other system Pressure is measured above the atmospheric presence and it is called gauge Pressure.

Absolute Pressure :-

It is defined as the Pressure which is measured with reference to absolute vaccum Pressure.

Gauge Pressure :-

It is defined as the Pressure which is measured with the help of Pressure measured instrument, in which the atmospheric Pressure is takes as date. The atmosphere Pressure on the scale is marked as zero.

Vaccum Pressure :-

~~It is defined as the Pressure which is measured with the help of a Pressure measure which is measured with the help of of a Pressure~~

It is defined as the Pressure below the atmospheric Pressure. The relationship between the absolute Pressure gauge Pressure and Vaccum Pressure.

(i) Absolute Pressure = Atmospheric Pressure + Gauge Pressure

$$\boxed{P_{ab} = P_{atm} + P_{gauge}}$$

(ii) Vaccum pressure = Atmospheric Pressure − Absolute Pressure

$$\boxed{P_{vaccum} = P_{atm} - P_{abs}}$$

when the local atmospheric Pressure is not given in a problem

$p = 100\ K/m^2$ or 10 m of water

The atmosphere pressure of sea level at $15^\circ C$.

" $101.3\ KN/m^2$ or $10.13\ N/cm^2$ in S.I unit.

Measurement of Pressures :-

The Pressure of a fluid may be measured by the following devices.

① Manometer
- Simple manometers
- Differential manometers
  - Piezometers
  - U-tube manometers
  - single column manometer

② Mechanical gauges
- Bourdon tube Pressure gauge
- Diaphragm pressure gauge
- Bellow pressure gauge
- Dead weight Pressure gauge

Manometers :-

Manometers are defined as the devices used for measuring the Pressure at a point in a fluid by balancing the column of fluid by the same or another column of the fluid.

Venturimeter :-

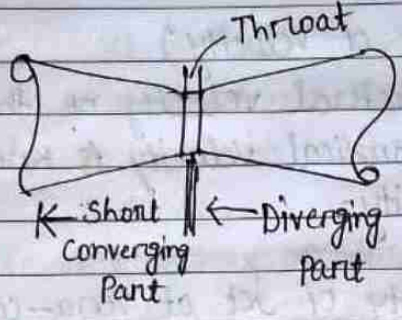
It is a devise used for measuring the rate of flow of a fluid flowing through a pipe.

→ A venturimeter consists of 3 parts-

① A short converging part

② Throat

③ Diverging part



$$\boxed{Q = A \times V}$$

$$Q = C_d \times \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh}$$

C_d → Co-efficient of discharge (0.98)

Orificemeter

It is a devise used for measuring the rate of flow of fluid through a pipe.

→ As the fluid flows through orifice, its contras & attached a parallel form at a distance d/2 from the plane of orifice.

→ The point at which the string line first became parallel is known as vena-contracta.

→ Beyond this section the jet diverses and attracted in the downward direction, by gravity.

Date
Page

Co-efficient of contraction

The ratio of the area of the jet at vena contracta to the area of the orifice is known as co-efficient of contraction.

$$C_c = \frac{a_c \text{ (area at venacontracta)}}{a \text{ (Area of orifice)}}$$

$$C_c = 0.613 \text{ to } 0.69$$

C_v = (coefficient of velocity)

→ It is the ratio of actual velocity of the jet at vena-contracta to the theoritical velocity is known as co-efficient of velocity.

$$C_v = \frac{\text{actual velocity of jet at vena-contracta}}{\text{Theoritical velocity}}$$

$$\Rightarrow C_v = \frac{V}{\sqrt{2gH}}$$ — Head under which water is flowing.

Co-efficient of discharge (C_d)

It is the ratio of actual discharge throw an oripiece to the theoritical discharge is known as co-efficient of discharge.

$$C_d = \frac{\text{Actual discharge}}{\text{Theoritical discharge}}$$

$$= \frac{\text{Actual Area} \times \text{Actual Velocity}}{\text{Theoritical Area} \times \text{Theoritical velocity}}$$

$$= C_c \times C_v$$

$$= \boxed{C_d = C_c \times C_v}$$

$(0.62 - 0.65)$

$$Q = C_d \times \frac{a_0 a_1}{\sqrt{a_1^2 - a_0^2}} \times \sqrt{2gh}$$

-: Notch :-

It is defiened as an opening in one side of a tank or reservoir, like a large orifice, with the uap stream liquid below the topage of the opening.

-: Loss of Energy in Pipe :-

When water flows in a pipe it experiences some resistance, motion due to which it's velocity & the head of the water availble is reduced.

There are 2 type of losses -

(I) Measure losses

(II) Minor losses

Major losses	Minor losses
→ Due to friction	→ Sudden enlargement of Pipe
	→ Sudden contraction of Pipe
	→ Bend in pipe
	→ pipe fitting
	→ An obstruction in pipe

-: Air compressor :-

AIR COMPRESSOR :-

It is a machine to compres the air & to raise it's Pressure.

→ The air compressor such air top atmosphere, comprese it then deliver the same under a have Pressure to a storage vessel.

→ From the storage vesel it may be convey by the Pipe line to a place where the supply of compresed air is required.

→ The comprased air is used for many purposes, such as-

(I) For operating
(II) pneumatics drill
(III) Riveters
(IV) road drills
(V) paint spraying
(VI) In starting & super charging of engine,
(VII) Gas turbine plant
(VIII) Z- engines
(IX) Air, motor ects.

→ It is also utilized in the operation of leave, pump etc.

→ In industry, compresed air is used for producing blast of air in blast furnances.

Classification of Air compressor :-

(1) According to working -
   (I) Receprocating compressor
   (II) Rotary compresor
(2) Acc. to action
   (a) single acting compresson
   (b) Double acting "
(3) Acc. to no. of stages
   (a) single stage compresor
   (b) Multistage compressor

Inlet Pressure →

→ It is the absolute pressure is air at the inlet of a compresser.

: Discharge Pressure :-

It is the absolute Pressure of air at the outled of a comprehor.

Compreshol ration or Pressure ratio :-

It is the ratio Pressure to the late Pressure.

Comprehesor capacity

→ It is the volume of air delivered by the compression.

$$\frac{m^3}{min} \text{ or } \frac{m^3}{sec}$$

Free air delivery (FAD)

It is the actual volume deliver by a compresor when reduced to the normal temp. & Pressure condition.

→ The capacity of a comprehesor is given in terms of free air delivery.

: Swept volume :-

It is the volume of air sucked by the compresion during it's sukson stroke.

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

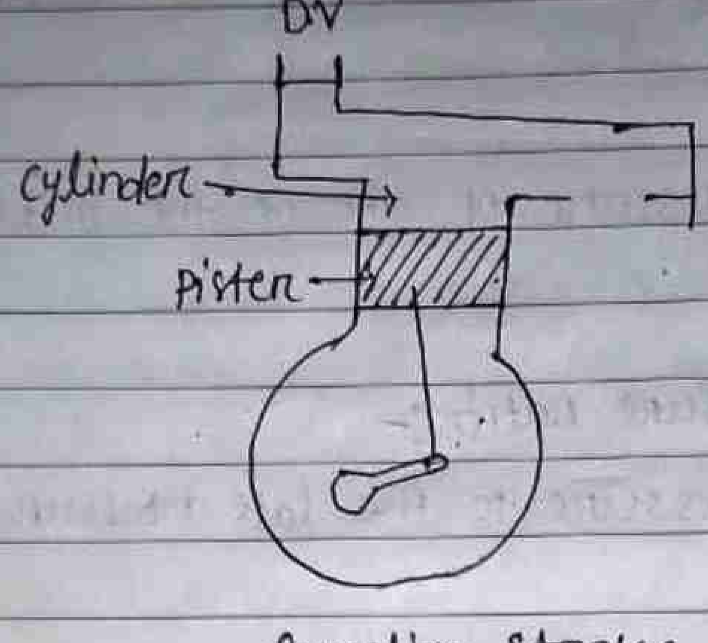
Mean Effective Pressure :-

Air Pressure on the compresion Piston keeps on changing with the moment on the Piston on the cylinder.

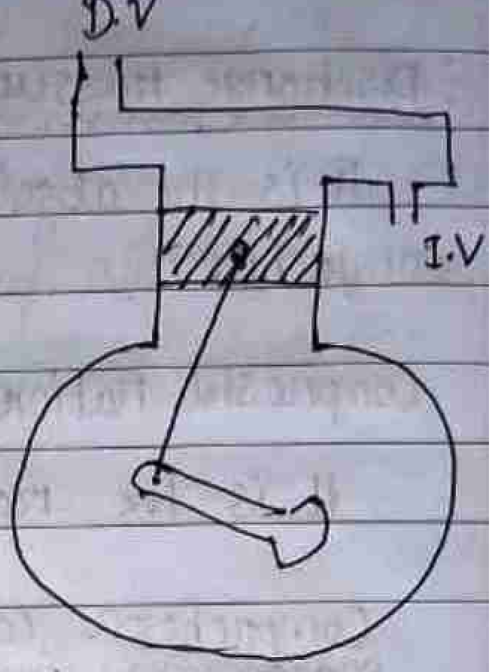
Mathematically,

$$M.e.P. = \frac{\text{Water Per cycle}}{\text{Stroke volume}}$$

Working of a single ...

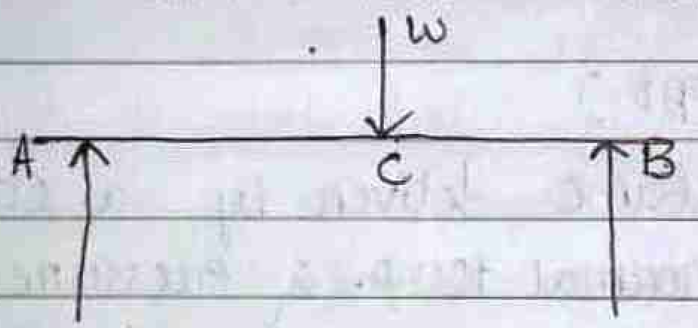


Suction Stroke



Delivery Stroke

Simple supported Bim with a Point load at it's mid Point



Taking of the movement about 'Zero'

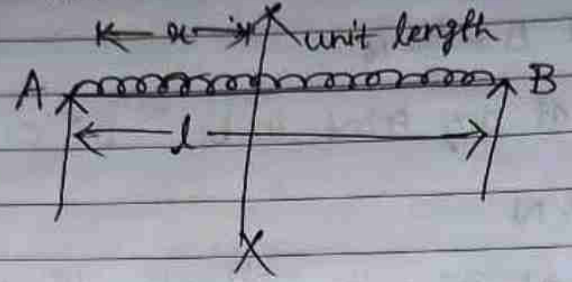
$$W = R_A + R_B$$

$$\Sigma M_A = 0$$

$$-R_B \times l + W \times \frac{l}{2} = 0$$

$$\Rightarrow -R_B \times l = \frac{-Wl}{2}$$

Simple Supported bim with a uniformly distributed load



$$R_A = R_B = \frac{wl}{2}$$

$$\Rightarrow R_A + R_B = wl$$

$$\Rightarrow R_A + R_A = wl$$

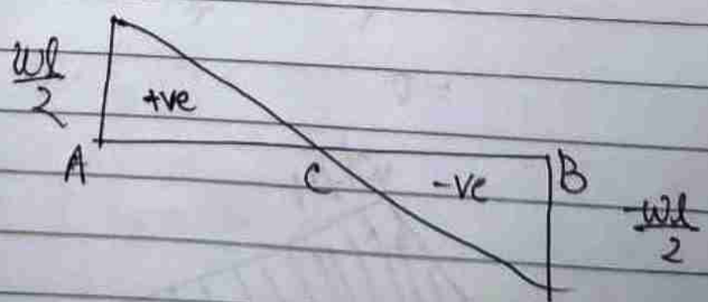
$$\Rightarrow 2R_A = wl \quad \Rightarrow R_A = \frac{wl}{2} = R_B$$

Shear force Analysis at any section 'x' at a distance 'x' from 'A'

$$R_A - wx = \frac{wl}{2} - x$$

At A, if $x=0$, $\frac{wl}{2}$

$$x = \frac{l}{2} \Big/ \frac{wl}{2} - \frac{wl}{2} = 0$$



Shear Force Analysis

$$S.F \text{ of } B = \frac{W}{2} N$$

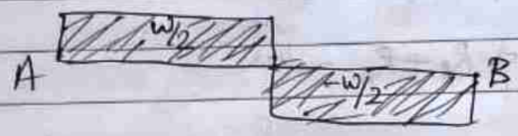
Shear force at any point in betn B & C but just before 'C'

$$= -\frac{W}{2} N$$

Shear force at Point 'C' $= \frac{-W}{2} + W = \frac{W}{2} N$

Shear force at any betn C & A

S.F.D



B.M. Analysis

$$B.M \text{ at } B = M_B = 0$$

Bending moment at a distance 'x' from 'B' & in between 'B' & 'C'.

$$R_B \times x = \frac{W}{2} x$$

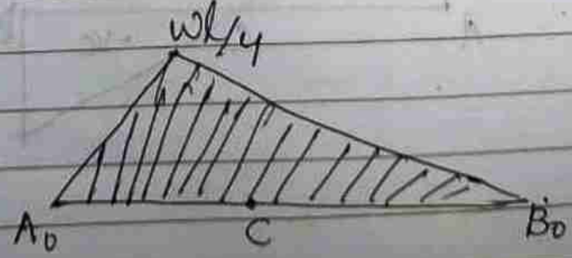
$$x = \frac{l}{2} \longrightarrow = \frac{W}{2} \times \frac{l}{2} = \frac{Wl}{4}$$

Bending moment at 'A' =

$$R_B \times l - W \times \frac{l}{2}$$

$$= \frac{W}{2} \times l - \frac{Wl}{2}$$

$$= 0$$



Point of contra flexure or Point of Inflection

In a bending ~~moment diagram~~ beam, a Point is known as A Point of contraflexure if it is a location where bending moment is zero. (changes it's sign)

In a bending moment diagram, it is the Point at which the bending moment curve intersect with the zero lie.

Simple bending

when the load Producing bending lies in the centroid plane Such that bending is not accompained by torsion when the bending is said to be simple bending.

Pure Bending

when a beam is subjected to such a system of bending law so that the shear force in the beam is zero. Then the beam is said to be subjected to Pure bending.

Such a case the bending moment constant.

Centoride

The centroid of the figure is that Point in the figure at which all the area may be assumed to be conc^n.

$$\bar{x} = \frac{A_1 x_1 + A_2 x_2 + \cdots\cdots +}{A_1 + A_2 + \cdots\cdots} = \frac{\Sigma A_2 x_2}{\Sigma A_i}$$

$$\bar{y} = \frac{A_1 y_1 + A_2 y_2 + \cdots}{A_1 A_2 + \cdots} = \frac{\Sigma A_i y_i}{\Sigma A_i}$$

B.M Analysis

Bending moment at any section at a distance from

$$M_x = R_A \cdot x - wx \cdot \frac{x}{2}$$

A $x=0$, $M_A = 0$

B, $x=l$, $M_B = R_A \times l - \frac{wl^2}{2}$

$$= \frac{wl}{2} \cdot l - \frac{wL^2}{2}$$

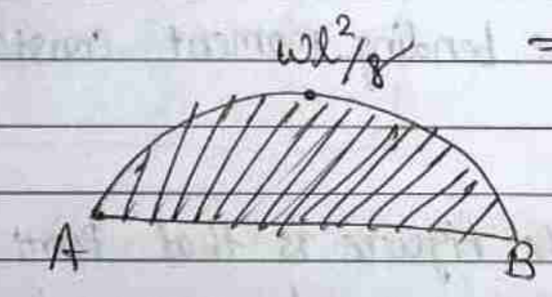
$$= \frac{wl^2}{2} - \frac{wl^2}{2}$$

$$= 0$$

$x = \frac{l}{2}$ $R_A \times \frac{l}{2} - \frac{wL}{2} \cdot \frac{l}{4}$

$$= \frac{wl}{2} \frac{l^2}{2} - \frac{wl^2}{8} = \frac{wl^2}{4} - \frac{wl^2}{8}$$

$$= \frac{2wl^2 - wl^2}{8}$$



Moment of Interia (M.I)

The moment of interia or the second moment of area about a given axis is the product of the element of area & square of the distance of the centoride from value of axis.

$$I_x = \Sigma y^2 \, dA$$

$$I_y = \Sigma x^2 \, dA$$

$$\boxed{I = MK^2}$$

Neutral Axis

Neutral axis of a beam in the axis at which the bending is zero.

Bending formula

$$\boxed{\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}}$$

Where, M = Bending Moment
I = Moment of Interia
σ = Intensity of stress
y = A distance from the central axis
E = Young's Modulus or Modulas Electricity
R = Radius of centroid surface

Torsion

A member is said to be under Pure torsion when it is subjected to a torque only, without being associated with any bending moment or axial force.

Assumption

The material of the shaft is homogenius & isotropic.
plane crossection of a circular shaft remains plain & circular before & after twisting.

All diameter of the crossection of the shaft remain straight with their length uchanged ; before & after twist.

The twist is informed along the length of the shaft

Stresses induced in the shapt due to torsion don't the Proportional limit.

→ The relative rotation betⁿ any two crossection of the stafp is proportional to the distance betⁿ them.

$$\boxed{\frac{T}{J} = \frac{\tau}{r} = \frac{G\theta}{L}}$$

where, T = Talk

J = Polar moment of intertia

$$J = \frac{\pi}{32} d^4$$

$$J = \frac{\pi}{32}(D^4 - d^4)$$

τ = Shear stress

R = Radius of shaft

G = Modulus of rigidity

θ = Angle of twist

L = Length of the rod

Application of Torsion

It applied in screw
It is also used in bridge many other structure & component.

Belt, Rope, chain drive

The belt or rope are used to transmit Power from one shaft to another by means of pully which rotate at the same speed or different speed.

→ The amount of Power transmitted depends upon the following factor. The velocity of the belt.
→ The tension under which the belt is blessed on the fully.
→ The arch of contact bet^n the belt & the smaller.
→ The condition under which the belt is used.

Selection of a Belt drive

→ Speed of the driving & given shaft
→ speed reduction ratio
→ Power to be transmitted
→ Center distance between the shaft
→ the drive requirement
→ shaft layout
→ Speed availble
→ Service condition

Slip of Belt

Some forward motion of the belt without carry the driving fully with it. This is called slip of the belt

Crip

when the belt passes ~~over~~ from the slack to the tight side, a shutter portion on the belt extends & it contracts again when the belt passes from the tight side to slack side.
→ Due to these change of length there is a relative motion

between the bend & cooly surface. This relative motion is known as creep.

Rope drive

The rope drives are used where a large amount of Power is to be transmitted.

→ There are 2 types of row.

(i) Fibre rope

(ii) wire rope

Chain drive

The chains are made of rigid limbs which are hinds together in order to Provide the necessary flexibility for warping around the driving & given shaft.

Advantage & disadvantage of chain drive over Belt / Rope drive

Adv- → No slip takes place

→ The chains are made of metals, so they occupi less.

→ It is used when the distance bet^n shaft & less.

→ It gives high transmission efficiency (about 98%)

→ The chain drive gives less load on the shaft.

→ The Production change is relatively high.

→ It needs accurate mounting & careful maintance.

Gear train

→ Two or more gears are made to mess with each other to transmit Power from one shaft to another.

This combination is called gear

(i) Simple gear train
(ii) Compound " "
(iii) Reverted " "
(iv) Epicyclic " "

(i) Defⁿ: When there is only one gear on each shaft is called simple gear train.

$$\text{Speed ratio} = \frac{N_1}{N_2} = \frac{T_2}{T_1}$$

$$\text{Train value} = \frac{N_2}{N_1} = \frac{T_1}{T_2}$$

→ The ideal gear accused to connect gear where a large centre distance is required to obtain the desire direction of motion of driven gear.

Compound gear

When there are more than one gear on a shaft is called compound gear train.

$$\text{Speed ratio} = \frac{\text{Speed of the first driver}}{\text{Speed of the last ~~driven~~ follower}}.$$

$$\text{Train value} = \frac{1}{\text{Speed ratio}}$$

Governor

The funⁿ of a governor is to regulate the mean speed of an engine, when there are variation in the load that means when the load on an engine increases, it is speed decreases. So, it become necessary to increase the supplier of working fluid.

→ On the other hand when the load on engine decreases, it's speed increases & less working fluid is required.

→ The governor automatically control the supply of working flu to the engine with the varry load condition & keeps the mean speed within the certain limit.

Types of Governor

There are 2 types of governor,
(i) centrifugal governor
(ii) Inertia governor

Centrifugal governor
- Pendulum type
- Loaded type
  - Dead weight
    - Porter
    - Proell
  - Spring control
    - Hartnel
    - Hartung
    - wilsm Hartnel
    - Pickering

Centrifugal

It is the governor as best on the balancing the centrifuga force on the rotating bulbs by equal & opposite radian force. It is known as controling force.

Term using Governor

Height of a Governor

→ It is the vertical distance from the centre of bulb to a point where the axes of world intersects the spindle axes

→ It is denoted by 'h'.

Equilibrium speed

It is the speed at which the governor bulbs, arms etc are in complete equilibrium & the slip doesn't move upward or downward.

Mean Equilibrium speed

It is the speed at the mean position of bulb or slip.

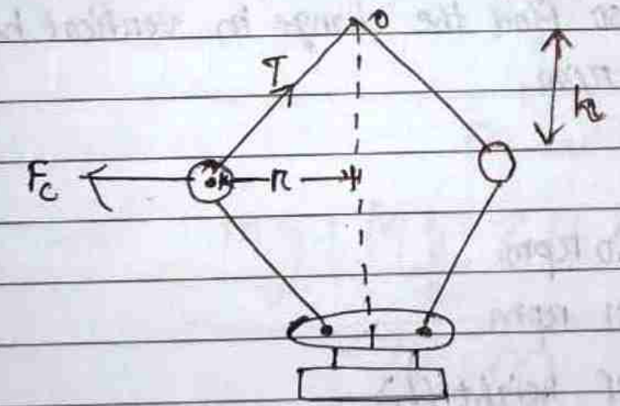
Maximum & minimum equilibrium speed

The speed at the maximum & minimum rotation of the bulb without tending to move - either way are known as maximum & min^m equilibrium speed respectively.

Sleeve lift

It is the vertical distance which the slip travel due to change in equilibrium speed.

Watt Governor



The simplest form of centrifugal governor is watt governor.
→ It is basically a conical Pendulum with links attach to a sleev up negligible mass where 'm' = mass of the bulb

w = weight of the ball = mg

T = Tension in arm

ω = Angular velocity $\frac{2\pi N}{60}$

r = radius of rotation

F_c = centrifugal force

h = height of governor.

Taking the moment about

$$F_c \times h = W \times r$$

$$\Rightarrow m\omega^2 r \times h = m \times g \times r$$

$$\Rightarrow h = \frac{g}{\omega^2}$$

$$= \frac{g}{\left(\frac{2\pi N}{60}\right)^2}$$

$$= \frac{9.81}{\left(\frac{2\pi N}{60}\right)^2} = \frac{895}{N^2} \text{ meter.}$$

Q. calculate the vertical height of a watt governer when it rotates at 60 pm also find the change in vertical height when speed increases to 61 rpm.

Ans. Given data,

N_1 = 60 rpm

N_2 = 61 rpm

Difference of height (h)

$$h_1 = \frac{895}{N_1^2} = \frac{895}{(60)^2} = \frac{\cancel{895}}{3600} = 0.248 \text{ m}$$

$$h_2 = \frac{895}{N_2^2} = \frac{895}{(61)^2} = \frac{895}{3721} = 0.24 \text{ m}$$

Date
Page

change in vertical height

$= h_1 - h_2$

$= 0.248 - \cancel{0.016}\, 0.24$

$= 0.008\ m$

$= 8\ mm$

$$\frac{F_C}{\tan\alpha} = \frac{m \times g \times \tan\alpha}{\tan\alpha} + \frac{M \cdot g}{2} \cdot \left(\frac{\tan\alpha}{\tan\alpha} + \frac{\tan\beta}{\tan\alpha}\right)$$

$$\Rightarrow \frac{m\omega^2 r}{\left(\frac{r}{h}\right)} = mg + \frac{M \cdot g}{2}(1+q)$$

$$\Rightarrow m\omega^2 \cancel{r} \times \frac{h}{\cancel{r}} = mg + \frac{Mg}{2}(1+q)$$

(Let $q = \frac{\tan\beta}{\tan\alpha}$)

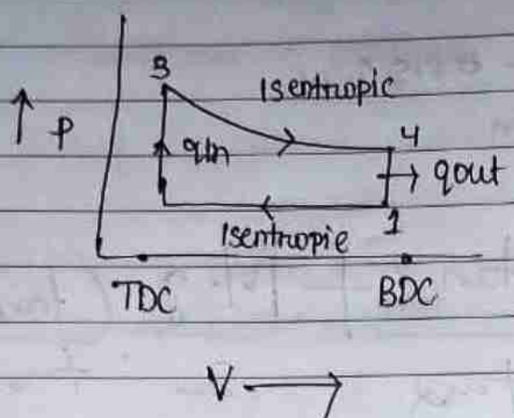
$$\Rightarrow h = \frac{mg + \frac{Mg}{2}(1+q)}{m\omega^2}$$

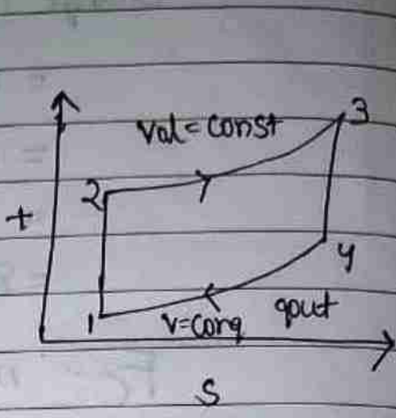
$$= \frac{mg + \frac{Mg}{2}(1+q)}{m} \times \frac{1}{\omega^2}$$

$$= \frac{m + \frac{M}{2}(1+q)}{m} \times \frac{g}{\omega^2}$$

$$= \frac{m + \frac{M}{\cancel{2}}\cancel{(1+1)}}{m} \times \frac{g}{\omega^2} = \frac{m+M}{m} \times \frac{g}{\omega^2}$$

Otto Cycle





1-2 → isentropic compression (entropy constant)
2-3 → constant heat addition
3-4 → isentropic expansion (entropy constant)
4-1 → constant heat rejection

The otto cycle is executed in a close system. The first law relation for any other process.

$$q - W = \Delta U \left(\frac{KJ}{Kg}\right) \text{ — ①}$$

The heat transfer to & work the working fluid, under to cold air standard assumption it is expressed as

$$q_{in} = q_{23} = U_3 - U_2 = C_v(T_3 - T_2) \text{ — ②}$$

$$q_{out} = q_{41} - (U_1 - U_4) = C_v(T_4 - T_1)$$

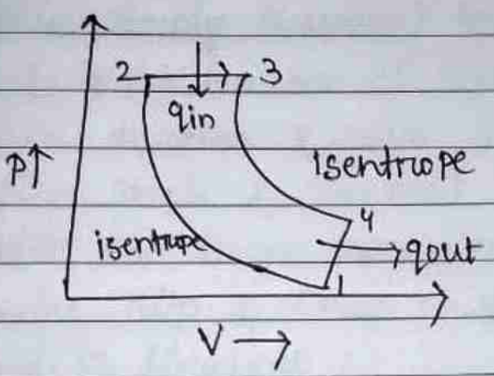
$$\eta_{otto} = \frac{W_{net}}{q_{in}} = \frac{q_{in} - q_{out}}{q_{in}}$$

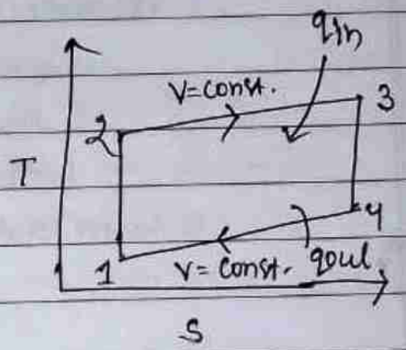
$$= \frac{q_{in}}{q_{in}} - \frac{q_{out}}{q_{in}}$$

$$= 1 - \frac{q_{out}}{q_{in}}$$

$$= 1 - \frac{T_1\left(\frac{T_4}{T_1} - 1\right)}{\left[T_2\left(\frac{T_3}{T_2} - 1\right)\right]}$$

Disel Engine





$$q_{in} = q_{23} = W_{23} + (\Delta V)_{23}$$

$$= P_2(V_3 - V_2) + (U_3 - U_2)$$

$$= C_p(T_3 - T_2) \quad \text{--- (1)}$$

$$q_{out} = q_{41} = -W_{41} - (\Delta U)_{41}$$

$$= U_4 - U_1 = C_v(T_4 - T_1)$$

$$(\eta_{th})_{Diesel} = \frac{W_{net}}{q_{in}} = 1 - \frac{q_{out}}{q_{in}}$$

$$= 1 - \frac{C_v(T_4 - T_1)}{C_p(T_3 - T_2)} = 1 - \frac{(T_4 - T_1)}{\gamma(T_3 - T_2)}$$

The cutoff ratio

It is defined as the ratio of the cylinder volume after and before the combusion.

$$\boxed{r_c = \frac{V_3}{V_2}}$$

1. Define limit of Proportionality ?
2. Define Hookes law ?
3. what is a shear force & bending moment ?
4. Define Poission's ratio ?
5. State of the Bending formula ?
6. Define Section modules ?
7. How Beams are classified ?
8. Define cantilever beam with example ?
9. Define simply supported beam with example ?
10. what is the function of torque converter.
11. Define torsion & write it's formula ?
12. Define simple & compound gear train ?
13. write the Power transmission device name ?
14. Define slip & Creap of Belt ?
15. what is Flywheel ?
16. Classify Governor & Define it ?
17. Defind fluid & write it's propention ?
18. Define density & write it's unit ?
19. write the relation between density & sp. weight ?
20. what is sp. gravity & write it's unit ?
21. what is Newtonian & Non-newtonian fluid.
22. Define surface tension & capillary ?
23. Define Pressure of a fluid & Pressurcheed ?
24. write the various Pressure measuring device ?
25. Define notch & it's uses ?
26. Differentiate between notch & orifice ?
27. state the continuity eq^n of incompressible fluid flow ?
28. state & explain the laws of fluid friction.
29. what do you mean by Hydraulic gradient & Energy gradient.
30. State the formula for Darly-weisbac eq^n of head due to friction.
31. writedown the advantage of compressor in Mines ?

(32) Differentiate between C.I engine & S.I engine ?
(33) Classify the Various type of Compressor & state the working principle of compressor ?
(34) State relationship I.H.P & B.H.P & mechanical efficiency ?
(35) Draw P-V & T-S diagram of otto cycle ?
(36) Draw P-V & T-S diesel cycle ?
(37) State various application of I.C Engine & the Mining Field ?
(38) Define I.H.P & B.H.P ?

Assignment - 1

2 mark → 1 to 8, 13, 14
5 mark → 1, 2, 3, 4
10 mark → 1, 2

Assignment - 2

2 mark → 17 to 21, 24, 26 to 29
5 mark → 5 to 8
10 mark → 5, 6

Assignment - 3

2 mark → 31 to 38, 9, 10
5 mark → 9 to 11
10 mark → 7, 8