GENERAL MECHANICAL ENGINEERING

Third Semester Mining Engineering.

Semester Examination	-	80
Class Test	-	15
Assignment	-	05
Total		100 Marks

TOPICS

	Periods
(1) Strength of Materials & Power transmission	- 16
(2) Elements of Hydraulics	- 13
(3) Compressed Air	- 09
(4) Internal Combustion Engines	- 06

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Strength of Materials & Power Transmission

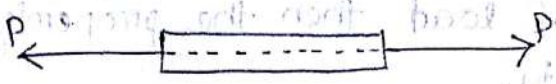
18/07/18

Mechanics of Solid :-

→ It is the branch of mechanics in which we study about the effect to force on a deformable body.

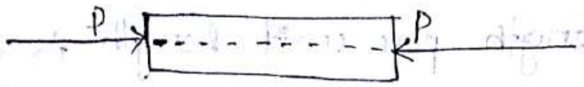
Tensile Force :-

→ It is the axially pull which tends to increase the length and decrease the area of cross section.



Compressive force :-

→ It is the axially push which tends to decrease the length & increase the area of cross section.



Stress :- (δ) (sigma) :-

→ It is the resisting force per unit area.

$$\boxed{\delta = F/A}$$

Unit

i) S.I. ⇒ $\delta = N/m^2$ or pascal

ii) C.G.S. ⇒ $\delta = \dfrac{dyne}{cm^2}$

$$\boxed{\begin{aligned} * \; N/mm^2 &= 10^6 N/m^2 \\ &= 1M \text{ pascal} \\ 1G\,Pa &= 10^3 MPa \end{aligned}}$$

Elasticity :-

→ If the body will re gain its original shape & size after the removal of external load then that property of body is known as elasticity.

Plasticity :-

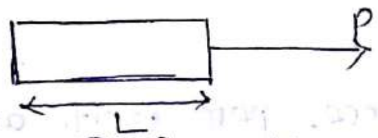
→ If the body will not return to its original shape & size after the removal of load then the property of body is known as plasticity.

Example- ploythene

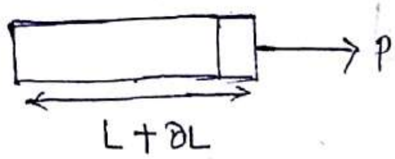
→ Here the body under goes permanent deformation.

Strain (e) :-

→ The change in length per unit length is known as strain



Before Deformation



After deformation.

Mathematically,

$$e = \frac{\text{Change in length}}{\text{Original Length}}$$

$$= \frac{(L + \partial L) - L}{L}$$

$$\boxed{e = \frac{\partial L}{L}}$$

Unit

→ It is unitless quantity.

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Longitudnal Strain or Linear Strain :-

→ The strain along the direction of applied force is known as longitudnal strain.

Lateral strain :-

→ The strain along the perpendicular to the direction of the applied force is known as lateral strain.

$$e_u = \frac{-\delta t}{t} \text{ or } \frac{-\delta d}{d}$$

t = thickness
d = diameter

Poission's Ratio (μ) :-

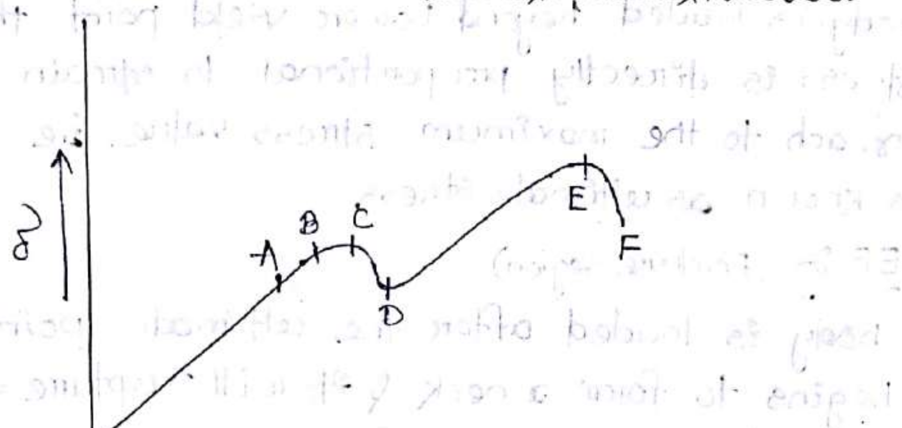
→ It is the ratio between Lateral strain to linear strain.

Mathematically,

$$\boxed{\mu = \frac{\text{Lateral strain}}{\text{Linear strain}}}$$

Imp

Stress - strain diagram for ductile material :- [5 mark]



A - Proportional limit

B - Elastic limit

C - Upper Yield point

D - Lower Yield Point

E - Ultimate point

F - Rupture point

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① Region OA (Proportionality Limit)

→ In this region the stress is directly proportional to strain

→ This line indicates limit of proportionality & Hooks Law is Applicable in this region.

② Region AB (Elastic Range)

→ If the body is loaded ~~beyond~~ beyond the proportionality limit that is 'A' then the body will deform ~~from~~ rapidly.

→ Here stress is not directly proportional to strain & the body will behave the property of elasticity.

③ Region CD (Yield Range)

→ If the body is further loaded beyond the elastic range then the body will behave the property of plasticity.

→ The point 'C' represent upper yield point i.e: sudden increase of strain without any increase of stress. The point 'D' represent the lower yield point.

④ Region DE :-

→ If the body is loaded beyond Lower yield point then again stress is directly proportional to strain & it will reach to the maximum stress value. i.e. point 'E' which is known as ultimate stress.

⑤ Region EF :- (Failure Region)

→ If the body is loaded after the ultimate point then it begins to form a neck & it will rupture at the point 'F'.

Internal IMP

Hooke's law :-

→ The law states that the stress is directly proportional to strain with in the proportionality limit.

i.e.- $\sigma \propto e$

$$\boxed{\sigma = Ee}$$

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-- where,

E = constant of proportionality which is known as- "Young's Modulus of Elasticity"

Units of Young Modulus :-

$$E = \frac{\delta}{e}$$

i) S.I. = N/m^2 or pascal

ii) C.G.S. = $dyne/cm^2$

Factor of safety :-

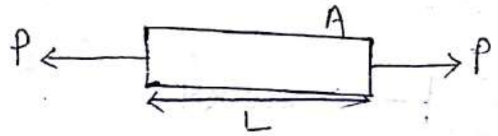
> It is the ratio between ultimate stress to alowable stress.

> Mathematically,

$$F.S. = \frac{\text{Ultimate stress}}{\text{Alowable stress}}$$

Imp

Elongation of a Bar :- 23/07/18



$\delta = eE$

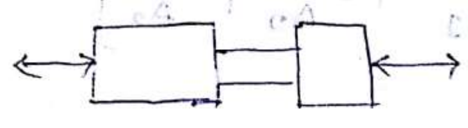
$\Rightarrow e = \frac{\delta}{E} = \frac{P/A}{E}$

$\Rightarrow \frac{\delta L}{L} = \frac{P}{AE}$

$\Rightarrow \boxed{\delta L = \frac{PL}{AE}}$

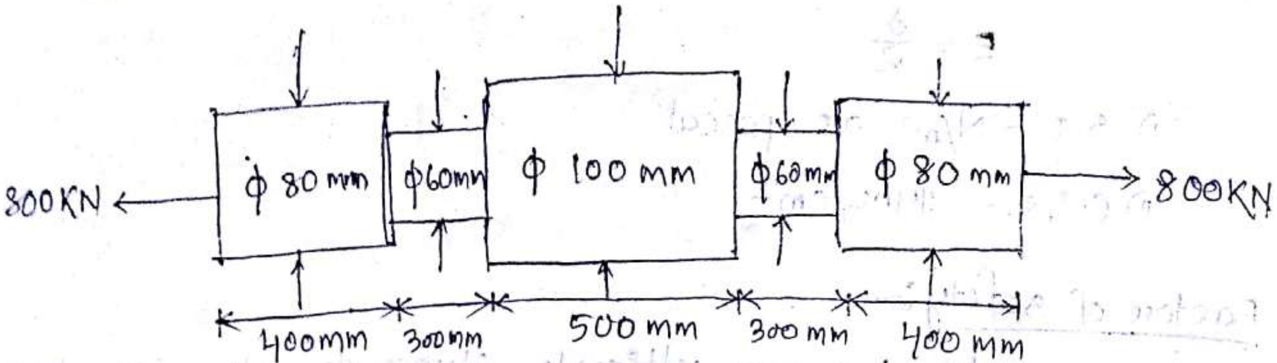
Principle of superposition :-

> It states that if a body is acted upon by a number of axial forces on various segment of the body then the net effect produce on the body is equal to summation of effect produce due to individual forces acting independently of the various segment



Problem-1

A circular steel bar of various cross section is subjected to a pull of 800 KN as shown in the Figure. Determine the extention of the bar; given E = 204 GPa.



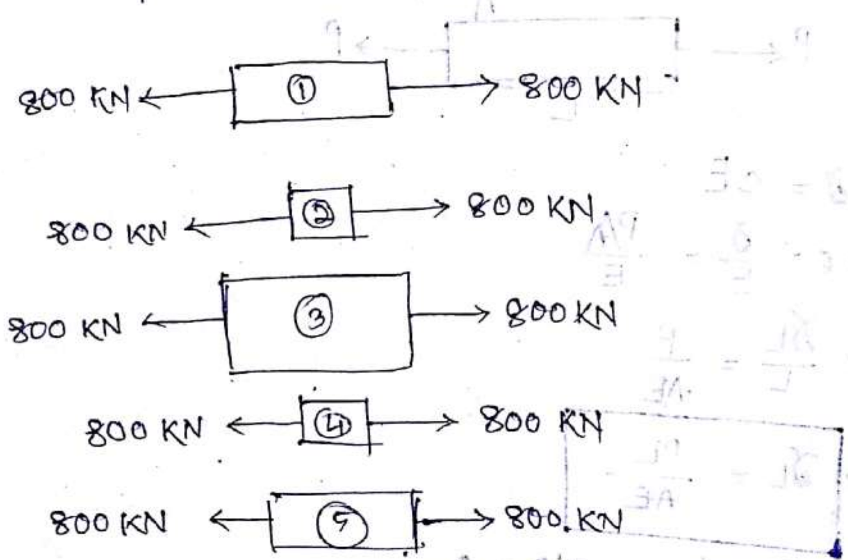
Solution :-

Given data :- $E = 204\ GPa = \cancel{204 \times 10^3\ MPa}$

$$\therefore A_1 = A_5 = \frac{\pi}{4} d^2 = \frac{\pi}{4} \times (80)^2 = 5026.54\ mm^2$$

$$A_2 = A_4 = \frac{\pi}{4} \times (60)^2 = 2827.43\ mm^2$$

$$A_3 = \frac{\pi}{4} (100)^2 = 7853.98\ mm^2$$



$$\delta L = \frac{PL}{AE}$$

$$= \delta L_1 + \delta L_2 + \delta L_3 + \delta L_4 + \delta L_5$$

$$= \frac{PL_1}{A_1 E} + \frac{PL_2}{A_2 E} + \frac{PL_3}{A_3 E} + \frac{PL_4}{A_4 E} + \frac{PL_5}{A_5 E}$$

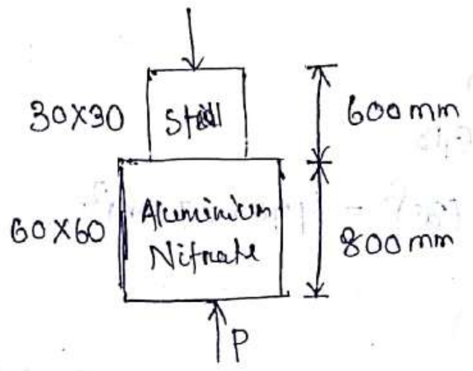
$$= \frac{P}{E} \left[\frac{2L_1}{A_1} + \frac{2L_2}{A_2} + \frac{L_3}{A_3} \right]$$

$$= \frac{800}{204\times} \left[\frac{2\times400}{5026.54} + \frac{2\times300}{2827.43} + \frac{500}{7853.98} \right]$$

$= 1.708\times$ mm Ans

Problem-2

A bar made up of two square section, one of steel & the other of aluminium as shown in the Fig. The bar is acted upon by a compressive force P. Determine the value of P is the total decrease in length of the bar is 0.3 mm. Take $E_s = 205$ GPa & $E_{Al} = 75$ GPa.



Solution:-

Given data for steel. $\delta L = 0.3$ mm

$L_s = 600$ mm

$A_s = 900\,mm^2$

$E_s = 205$ GPa

$= \cancel{205\times10^3\ MPa}$

For Aluminium - $L_{Al} = 800$ mm

$A_{Al} = 3600\,mm^2$

$E_s = 75$ GPa

$\cancel{75\times10^3\ MPa}$

$\delta L = \delta L_s + \delta L_{Al}$

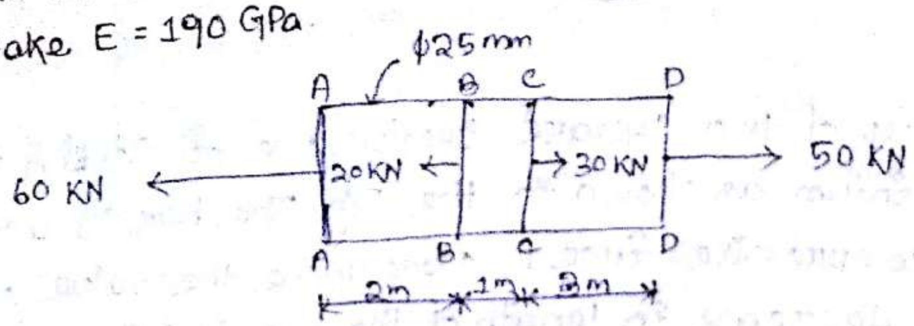
$\Rightarrow \delta L = \frac{PL_s}{A_s E} + \frac{PL_{Al}}{A_{Al} E}$

$\Rightarrow 0.3 = P \left(\frac{600}{900\times205\times} + \frac{800}{3600\times75\times} \right)$

$= 48.27$ KN Ans

Problem-3

A steel bar of 25 mm diameter is acted open by forces as shown in figure. what is the total elongation of the bar take E = 190 GPa



Solution

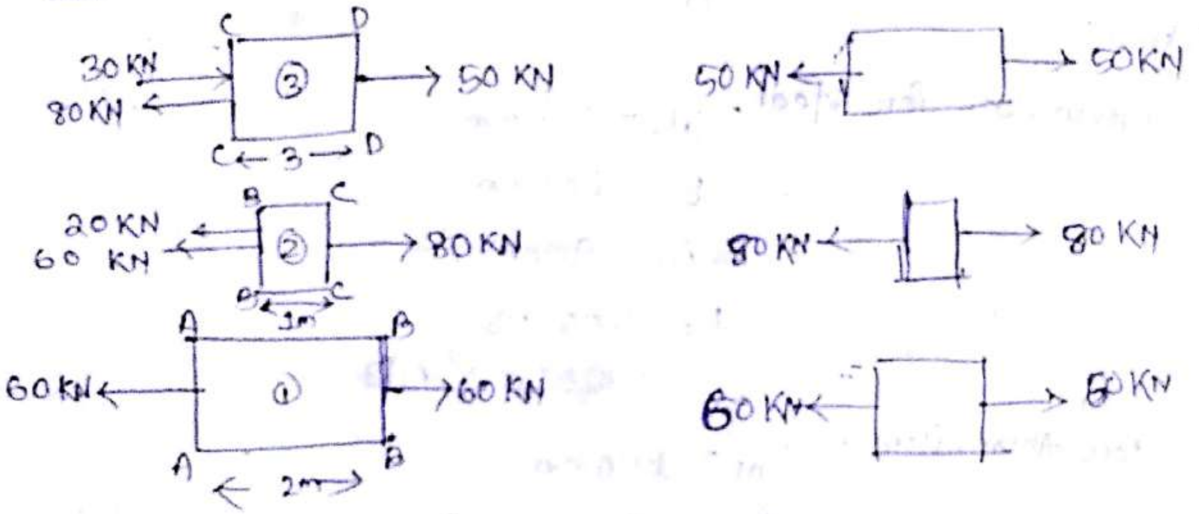
Given data:-

$d = 25 mm$

$E = 190$ GPa

$A = \frac{\pi}{4} d^2 = \frac{\pi}{4}(25)^2 = 490.87\ mm^2$

FBD



$\therefore\ \delta L = \delta L_1 + \delta L_2 + \delta L_3$

$= \frac{PL_1}{A_1 E} + \frac{PL_2}{A_2 E} + \frac{PL_3}{A_3 E}$

$= \frac{50 \times 3000 + 80 \times 1000 + 60 \times 2000}{490.87 \times 190}$

$= 3.75$ mm Ans

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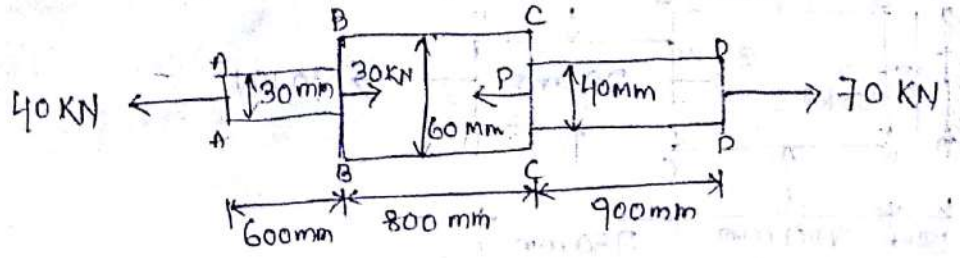
Problem - 4



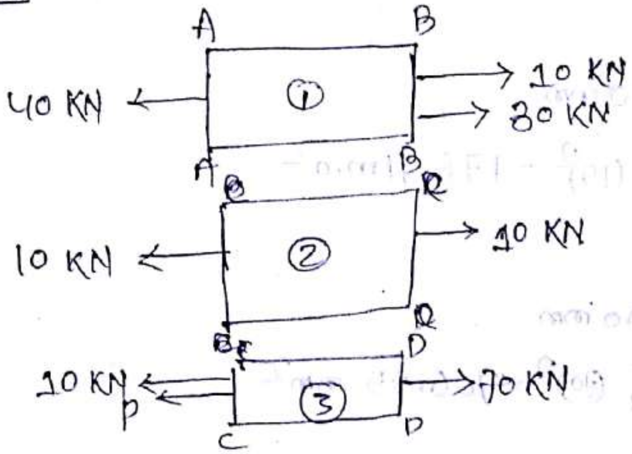
$E = 202$ GPa

i) Find 'P' for equilibrium

ii) Find ΔL

Solution

FBD



(i) For section ③

$$P + 10 = 70 \text{ KN}$$

$$\Rightarrow P = 70 - 10 = 60 \text{ KN}$$

(ii) $\delta L = \delta L_1 + \delta L_2 + \delta L_3$

$$= \frac{PL_1}{A_1 E} + \frac{PL_2}{A_2 E} + \frac{PL_3}{A_3 E}$$

$$= \frac{40 \times 600}{18000 \times 202} + \frac{10 \times 800}{48000 \times 202} + \frac{70 \times 900}{36000 \times 202}$$

~~= 0.95 mm~~

$= 0.016$ mm Ans

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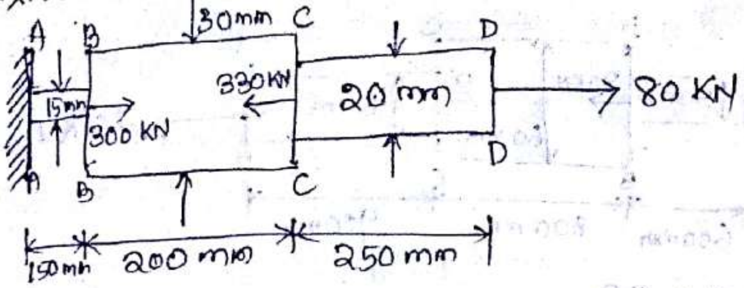
Problem-5:-



$E = 205$ GPa

1) Find ΔL?

Given data:-

$E = 205$ GPa

For section ①

$L_1 = 150$ mm

$A_1 = \frac{\pi}{4}(15)^2 = 176.71 \, mm^2$

For section ②

$L_2 = 200$ mm

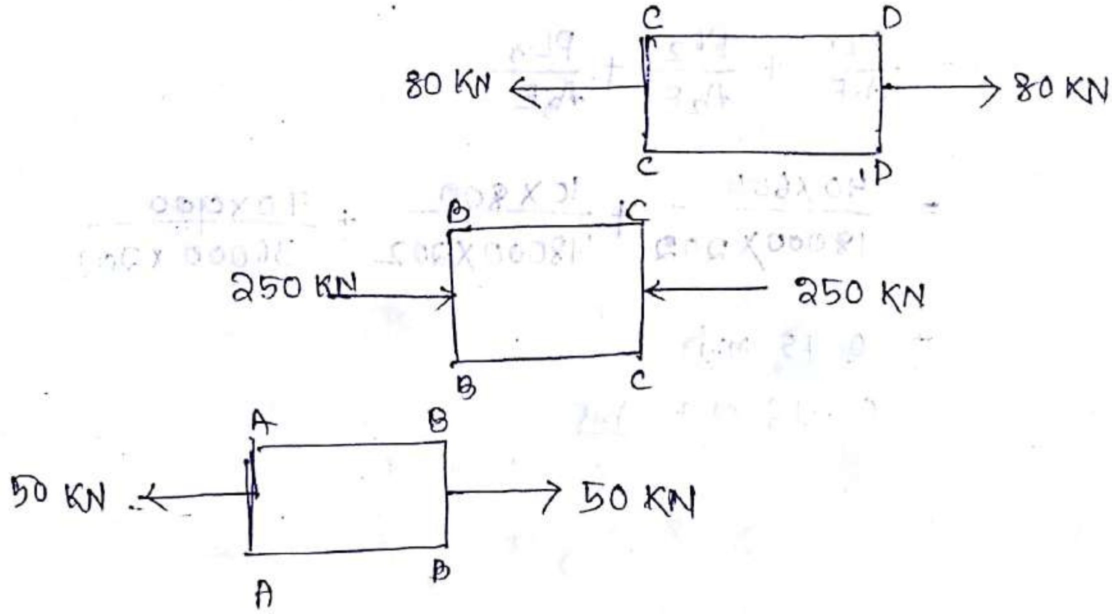
$A_2 = \frac{\pi}{4}(30)^2 = 706.85 \, mm^2$

For section ③

$L_3 = 250$ mm

$A_3 = \frac{\pi}{4}(20)^2 = 314.15 \, mm2$

Freebody Diagram



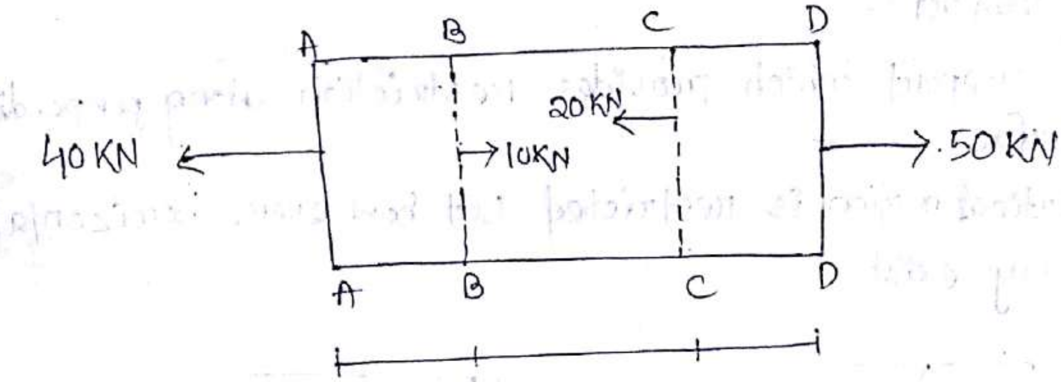
$$\Delta L = \delta L_1 - \delta L_2 + \delta L_3$$

$$= \frac{PL_1}{A_1 E} - \frac{PL_2}{A_2 E} + \frac{PL_3}{A_3 E}$$

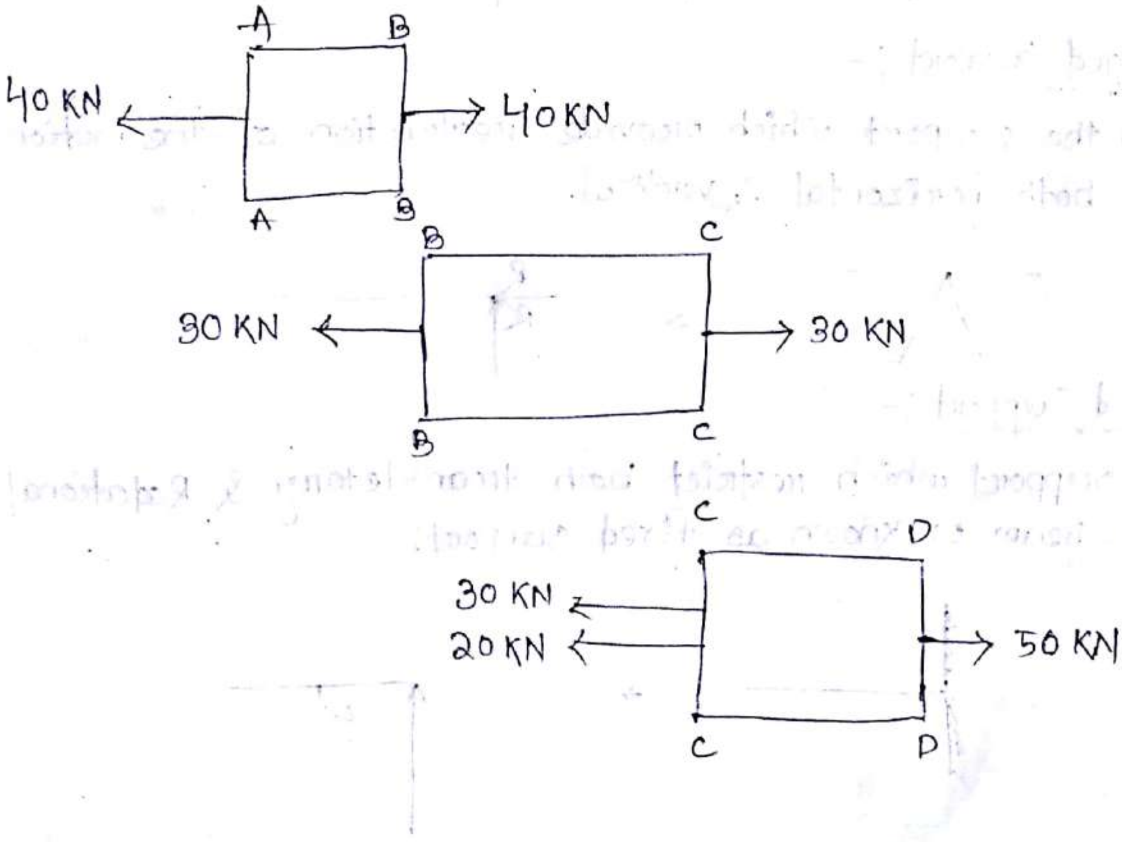
$$= \frac{50 \times 150}{176.71 \times 205} - \frac{250 \times 200}{706.85 \times 205} + \frac{80 \times 250}{314.15 \times 205}$$

$$= 0.173 \text{ mm} \quad \text{Ans}$$

Problem-6



Freebody Diagram



Shear force & Bending Moment :-

* Beam :-

It is structural member which is subjected to vertical Load only.

Types of Support :-

i) Roller support

ii) Hinged support

iii) fixed support.

i) Roller support :-

→ It is the support which provides restriction along perpendicular to the surface.

→ Here vertical motion is restricted but how ever horizontal motion may exist

ii) Hinged Support :-

→ It is the support which provide restriction of the motion along both horizontal & vertical.

iii) Fixed Support :-

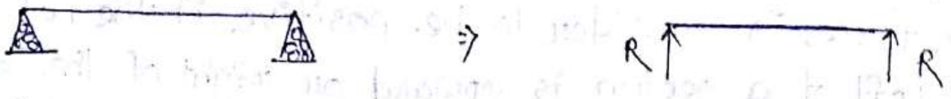
→ The support which restrict both translatary & Ratational of the beam is known as fixed support.

Types of beam :-

1) Simple supported Beam
ii) Cantilever Beam
iii) Contineous Beam
iv) Over hang Beam.

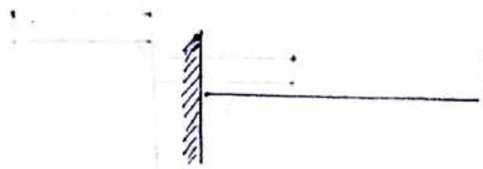
(1) Simple supported Beam :-

If a beam is supported by two runner support or one roller and another hinged at the two end of beam is Known as simple supported beam.



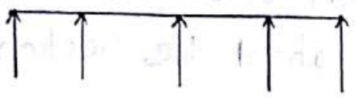
(ii) Cantilever Beam :-

→ If one end of the beam is supported by fixed support & othere end is free then the beam is Known as cantilever beam.



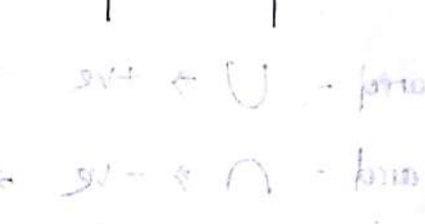
iii) Continious Beam :-

If the beam is supported by more than two support then the beam is known as continious beam.



iv) Overhang Beam :-

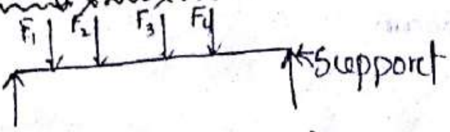
If some portion of the simple supported beam remain - free at the end then the beam is known as the overhang beam.



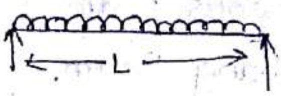
06/08/18

Types of Load acting on Beam :-

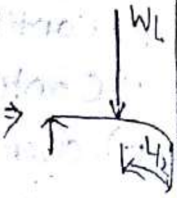
I) Point Load →



II) UDL (Uniform Distributed Load) →



→

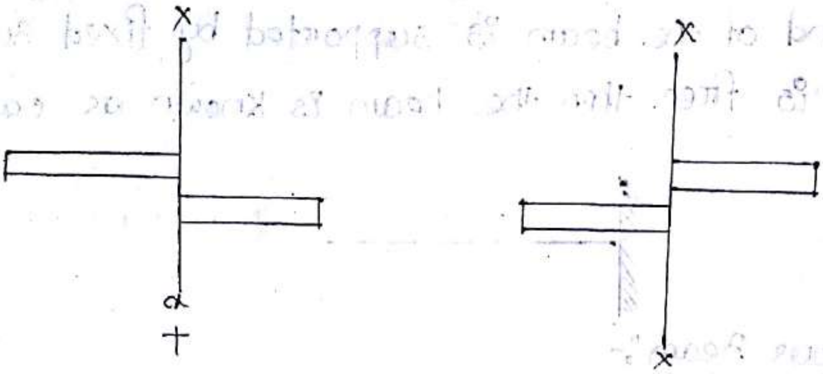


Shear force :-

Shear force at a section of a beam is the sum of all the forces on one side of the section.

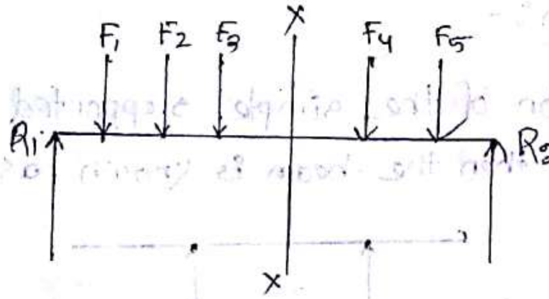
Sign Convention :-

Shear force is consider to be positive if the net force to the Left of a section is upward or right of the section is down-ward.



Bending Moment :-

Bending moment at a section of a beam is defined as the alzebric sum of the moment about the section of all the forces on one side of the section.



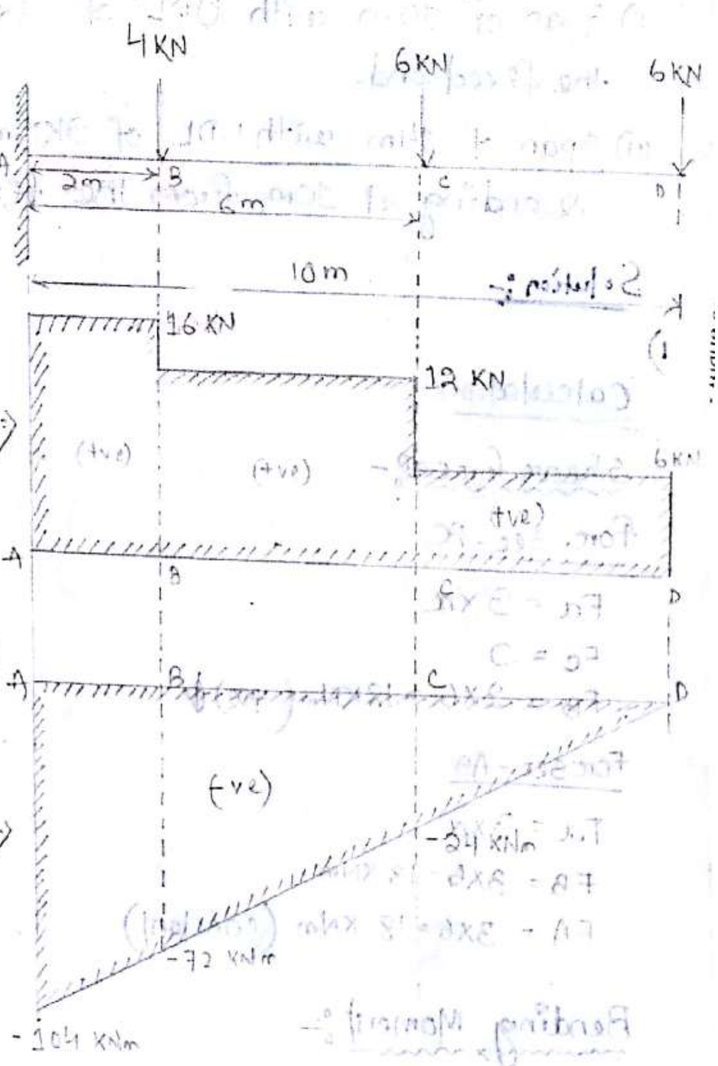
Sign Convention :-

I) Concavity upward - U → +ve → (Sagging BM)

II) Convexity upward - ∩ → −ve → (Hogging BM)

Problem -1

A cantilever of 10m span carries load of 4KN & 6KN at 2m & 6m respectively from the fixed end along with another load & 6KN at the free end. Draw the shear force & bending moment diagram.



Solution

For Shear Force

Section CD

$F_X = 6\text{ KN} \downarrow (+ve)$

It is constant between C & D

Section BC

$F_X = 6\text{KN} + 6\text{KN} = 12\text{ KN} \ (+ve)$

It is constant between B & C

Section AB

$F_X = 4\text{ KN} + 6\text{KN} + 6\text{KN} = 16\text{ KN} (+ve)$

It is constant between A & B

For Bending Moment :-

Section CD

$M_X = 6 \times x = -6x$ KNm

$$\boxed{\begin{aligned} M_D &= 0 \\ M_C &= -24\text{ KNm} \end{aligned}}$$

Section BC

$M_X =$

$= -6x - 6 \times (x-4)$ KNm

$M_C = -24$ KNm

$$\boxed{M_B = -72\text{ KNm}}$$

Section AB

$M_X = -6x - 6 \times (x-4) - 4(x-8)$

$M_B = -72$ KNm

$$\boxed{M_A = -104\text{ KNm}}$$

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Problem-2 09/08/18

Draw the shear force & bending moment diagram in the following cases of ~~cantever~~ cantilever.

I) Span of 10m with uniformly distributed Load & 3 KN/m for 6m starting from the free end.

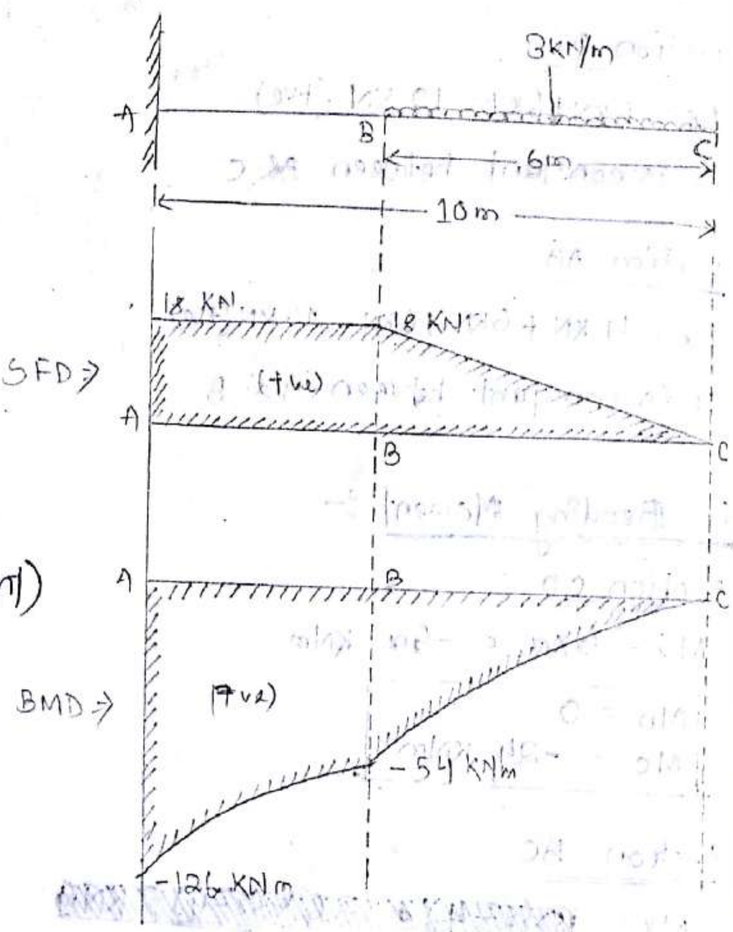
II) Span of 10 m with UDL of 3KNm for 6m starting from the fixed end.

III) Span of 14m with UDL of 3KNm for 6m starting from 4m & ending at 10m from the fixed end.

Solution:-

1)

Calculation



Shear force:-

For sec - BC

$F_x = 3 \times x$

$F_C = 0$

$F_B = 3 \times 6 = 18 KNm$ (+ve)

For sec - AB

$F_x = 3 \times x$

$F_B = 3 \times 6 = 18$ KNm

$F_A = 3 \times 6 = 18$ KNm (constant)

Bending Moment:-

For sec BC

$M_x = (3x)\left(\frac{x}{2}\right)$

$= \frac{3x^2}{2}$

$M_C = \boxed{0}$

$M_B = \frac{3 \times 6^2}{2} = \boxed{-54 \text{ KNm}}$

Section AB

$M_x = 18\ (x-3)$

$M_B = -54$ KNm

$M_A = 18\ (10-3) = \boxed{-126 \text{ KNm}}$

11) Calculation:-

For, Shear force :-

Section- BC

$F_x = 0$

$F_C = 0$

$F_B = 0$

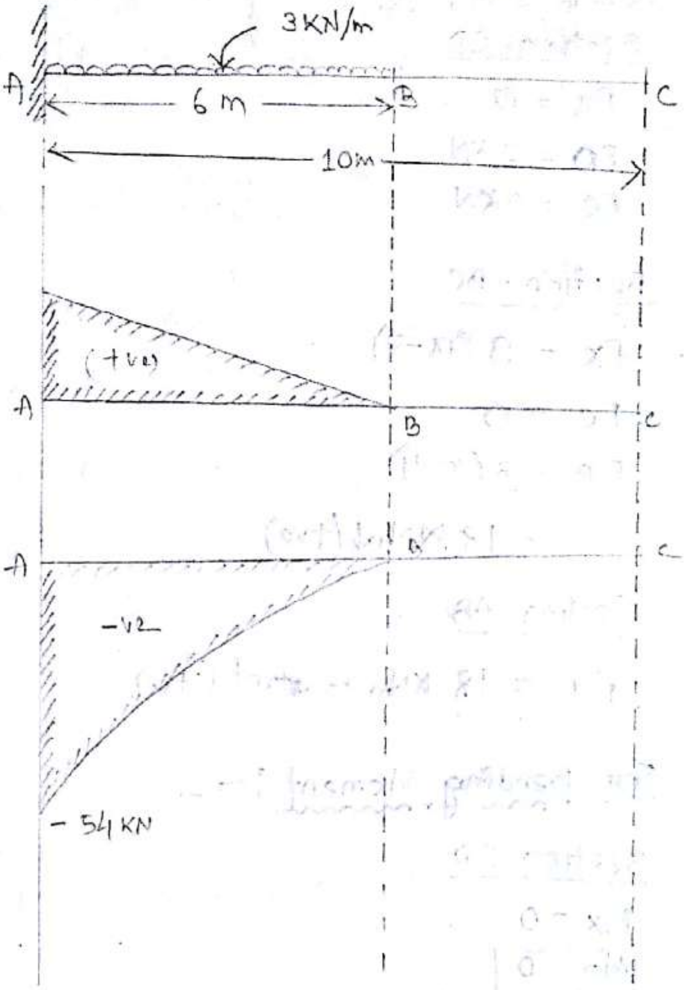
Section - AB

$F_x = 3(x-4)$

$F_B = 0$

$F_A = 3(10-4)$

$= 18$ KN ↓(+ve)



For Bending Moment :-

Section-BC

$M_x = 0$

$M_C = 0$

$M_B = 0$

Section- AB

$M_x = 3(x-4)\left(\frac{x-4}{2}\right)$

$M_B = 0$

$M_A = 3 \times (10-4)\left(\frac{10-4}{2}\right)$

$= 3 \times 6 \times \frac{6}{2}$

$= -54$ KN ↓ (-ve)

iii) Calculation

For Shear force :-

Section- CD

$F_x = 0$

$F_D = 0$ KN

$F_C = 0$ KN

Section - BC

$F_x = 3(x-4)$

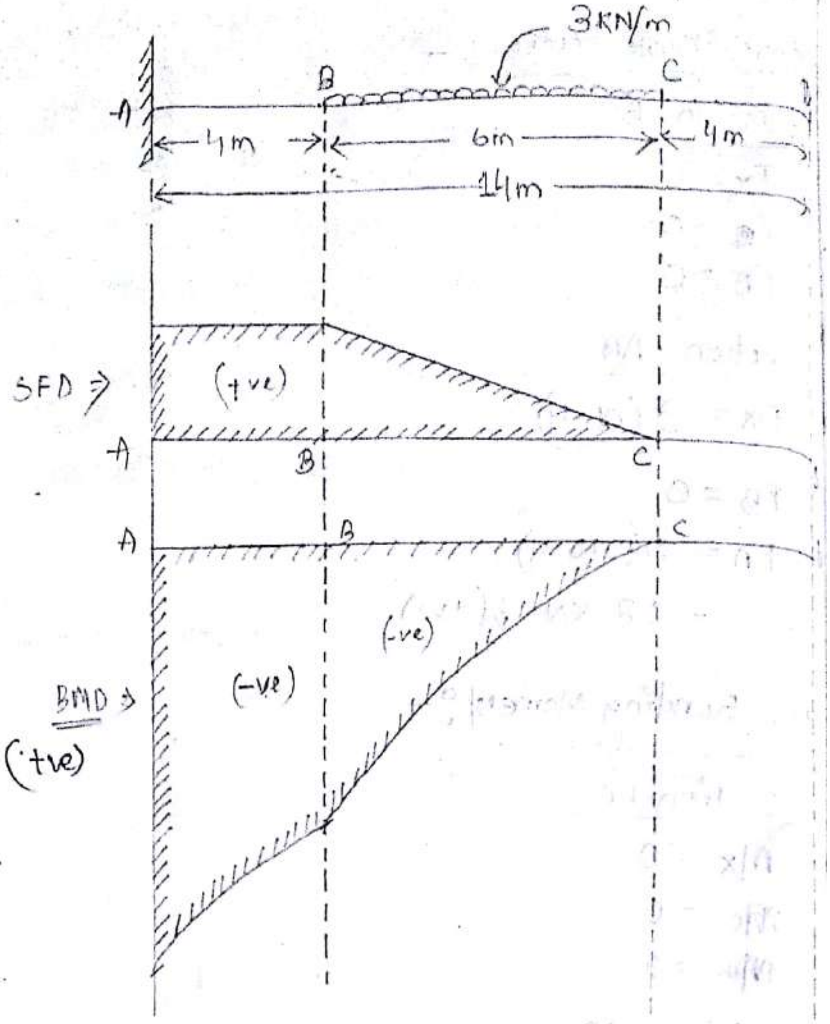
$F_C = 0$

$F_B = 3(10-4)$

$= 18$ KNm (+ve)

Section- AB

$F_x = 18$ KNm constant (+ve)



For Bending Moment :-

Section- CD

$M_x = 0$

$\boxed{M_D = 0}$

$M_C = 0$

Section BC

$M_x = 3(x-4)\left(\frac{x-4}{2}\right)$

$\boxed{M_C = 0}$

$M_B = 3(10-4)\left(\frac{10-4}{2}\right)$

$= 3 \times 6 \times 3$

$= -54$ KNm (-ve)

Section AB

$M_x = 18(x-7)$

$M_B = \boxed{-54 \downarrow (-ve)}$

$M_A = 18(14-7)$

$= \boxed{-126 \text{ KNm} \downarrow (-ve)}$

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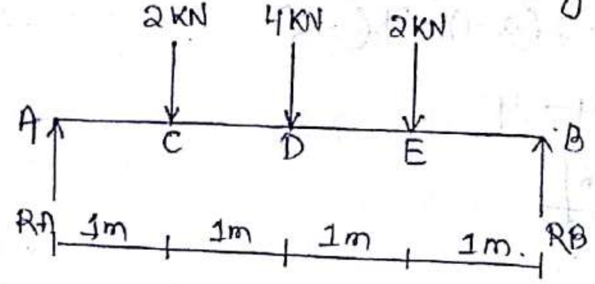
Date- 13/08/2018

Problem = 3

Draw Shear Force & Bending Moment diagram for simply supported beam loaded as shown in the figure.



Solution

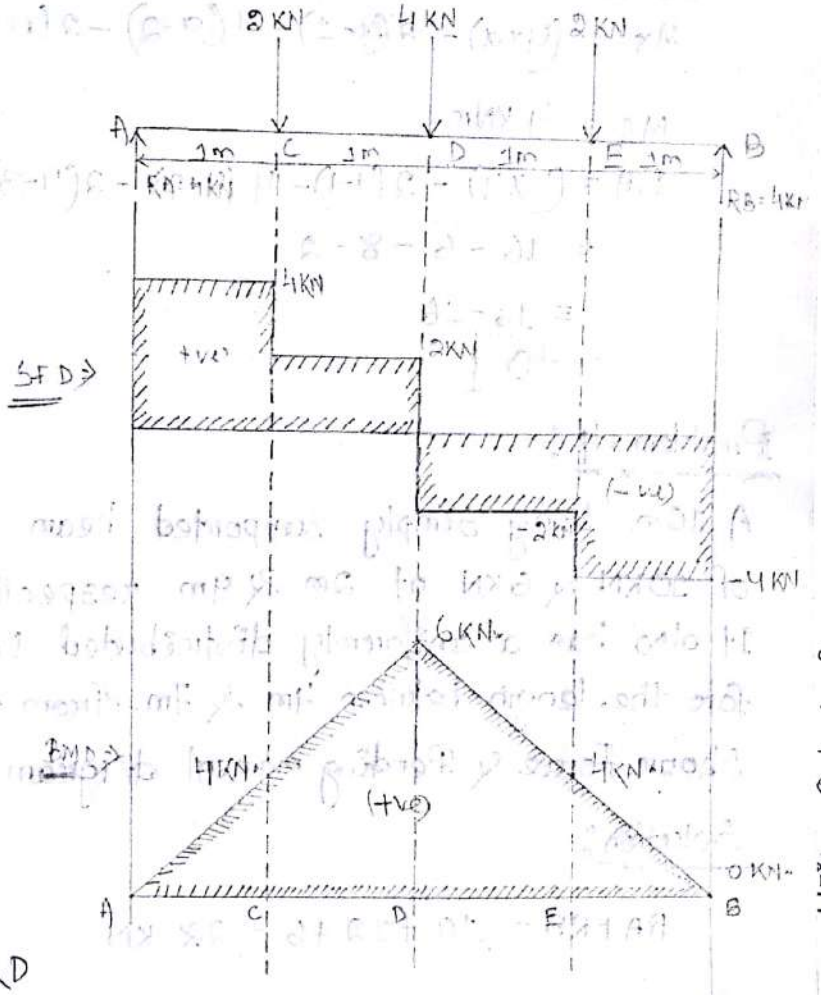
$\boxed{R_A + R_B = 2+4+2 = 8\ KN}$

Taking moment about 'A'

$2\times1 + 4\times2 + 2\times3 = R_B \times 4$

$\Rightarrow 4R_B = 16$

$\Rightarrow \boxed{R_B = 4\ KN}$



For shear Force :-

Section- EB

$F_x = -4\ KN$

It is constant for E & B

Section- DE

$F_x = -4+2 = -2\ KN$

It is constant for E & D

Section- CD

$F_x = -4+2+4 = 2\ KN$

It is constant for C & D

Section-AC

$F_x = -4+2+4+2 = 4\ KN$

It is constant for A & C

For Bending Moment :-

Section EB

$M_x = 4\times x$

$M_B = 4\times0 = \boxed{0}$

$M_E = 4\times1 = \boxed{4\ KNm}$

Section-DE

$M_x = 4\times x - 2(x-1)$

$M_E = 4\times1 - 2(1-1)$
$= 4-0 = 4\ KNm$

$M_D = (4\times2) - 2(2-1)$
$= 8-2 = \boxed{6\ KNm}$

Section CD

$M_x = (4 \times x) - 2(x-1) - 4(x-2)$

$M_D = 6$ KNm

$M_C = (4\times3) - 2(3-1) - 4(3-2)$

$= 12 - 4 - 4$

$= \boxed{4 \text{ KNm}}$

Section-AC

$M_x = (4\times x) - 2(x-1) - 4(x-2) - 2(x-3)$

$M_C = 4$ KNm

$M_A = (4\times4) - 2(4-1) - 4(4-2) - 2(4-3)$

$= 16 - 6 - 8 - 2$

$= 16 - 16$

$= \boxed{0}$

Problem - 4 :-

A 10m. Long simply supported beam carries two points Load of 10KN & 6KN at 2m & 9m respectively from the Left hand It also has a uniformly distributed Load of 4KN/m run fore the length between 4m & 7m. from the Left hand. Draw the Shear Force & Bending moment diagram.

Solution:-

$RA + RB = 10 + 12 + 6 = 28$ KN

Taking moment about A

$RB \times 10 = (6\times9) + (12\times5.5) + (10\times2)$

$\Rightarrow RB \times 10 = 54 + 66 + 20$

$\Rightarrow RB \times 10 = 140$

$\Rightarrow RB = \frac{140}{10} = \boxed{14 \text{ KN}}$

$\therefore RA + RB = 28$

$\Rightarrow RA = 28 - RB$

$= 28 - 14 = \boxed{14 \text{ KN}}$

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For Shear Force :-

Section FB

$F_X = -14\,KN$ (constant)

Section - EF

$F_X = -14 + 6 = -8\,KN$ (constant)

Section DE

$F_X = -14 + 6 + 4(x-3)$

$F_D = -14 + 6 + 4(6-3)$

$= -14 + 6 + 12$

$= 4\,KN$

Section CD

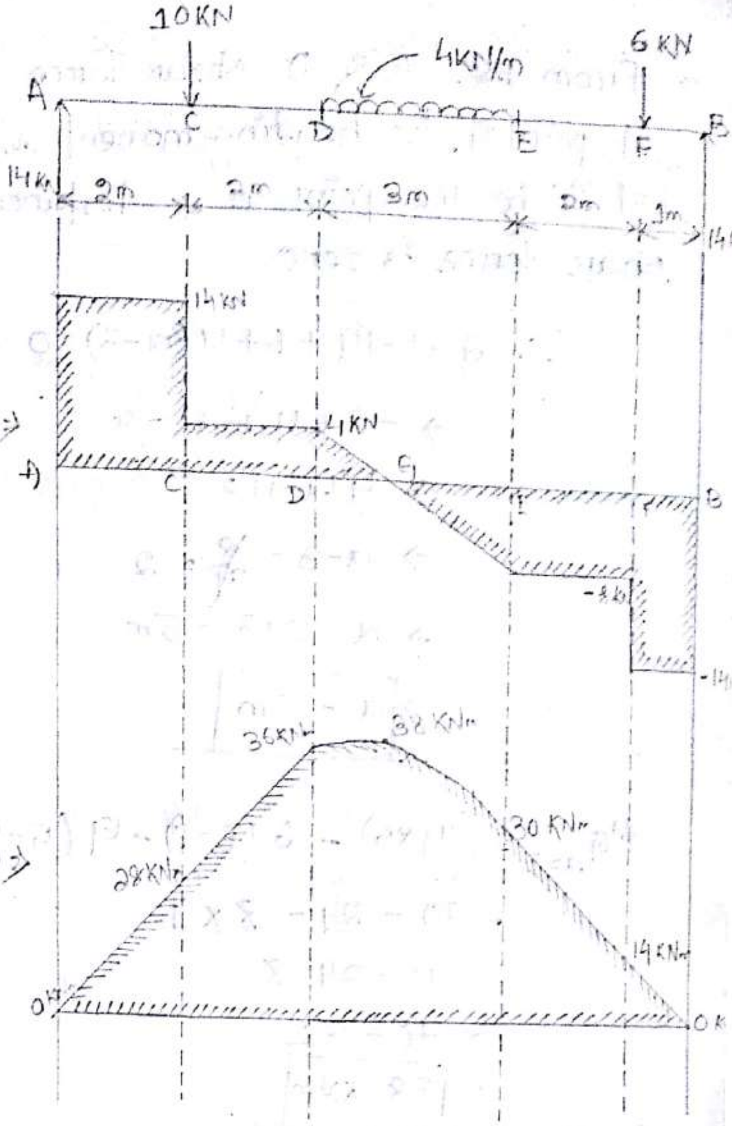
$F_X = -14 + 6 + 12$

$= 4\,KN$ (constant)

Section - AC

$F_X = -14 + 6 + 12 + 10$

$= 14\,KN$ (Constant)



For Bending Moment :-

Section FB

$M_X = 14 \times x$

$M_B = 0$

$M_F = 14 \times 1 = \boxed{14\,KNm}$

Section EF

$M_X = (14 \times x) - 6(x-1)$

$M_F = 14\,KNm$

$M_E = (14 \times 3) - 6(3-1)$

$= 42 - 12$

$= \boxed{30\,KNm}$

Section - DE

$M_x = (14 \times x) - 6(x-1) - 4(x-3)\left(\frac{x-3}{2}\right)$

$M_E = 30\,KNm$

$M_D = (14 \times 6) - 6(6-1) - 4(6-3)\left(\frac{6-3}{2}\right)$

$= 84 - 30 - \left(\cancel{12}^{6} \times \frac{3}{\cancel{2}}\right)$

$= 84 - 30 - 18$

$= 84 - 48$

$= \boxed{36\,KNm}$

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→ From ~~the~~ E & D shear force diagram changes its sign at point G, So bending moment will be maximum at point G.

↳ Let 'G' be the point at a distance x from B where share force is zero.

$$\therefore G = -14 + 6 + 4(x-3) = 0$$

$$\Rightarrow -8 + 4(x-3) = 0$$

$$\Rightarrow 4(x-3) = 8$$

$$\Rightarrow x - 3 = \cancel{\frac{8}{4}} = 2$$

$$\Rightarrow x = 2 + 3 = 5m$$

$$\Rightarrow \boxed{x = 5m}$$

$$M_{G_{x=5}} = (14 \times 5) - 6(5-1) - 4(5-3)\left(\frac{5-3}{2}\right)$$

$$= 70 - 24 - 8 \times 1$$

$$= 70 - 24 - 8$$

$$= 70 - 32$$

$$= \boxed{38 \text{ KNm}}$$

Section - CD

$$M_x = (14 \times x) - 6(x-1) - 12 \times (x - 4.5)$$

$$M_D = (14 \times 6) - 6(6-1) - 12 \times (6 - 4.5)$$

$$= 84 - 30 - 18$$

$$= 84 - 48$$

$$= \boxed{36 \text{ KNm}}$$

$$M_C = (14 \times 8) - 6(8-1) - 12 \times (8 - 4.5)$$

$$= 112 - 42 - 46$$

$$= \boxed{28 \text{ KNm}}$$

Section AC

$$M_x = (14 \times x) - 6(x-1) - 12 \times (x - 4.5) - 10(x-8)$$

$$M_C = 28 \text{ KNm}$$

$$M_A (x = 10)$$

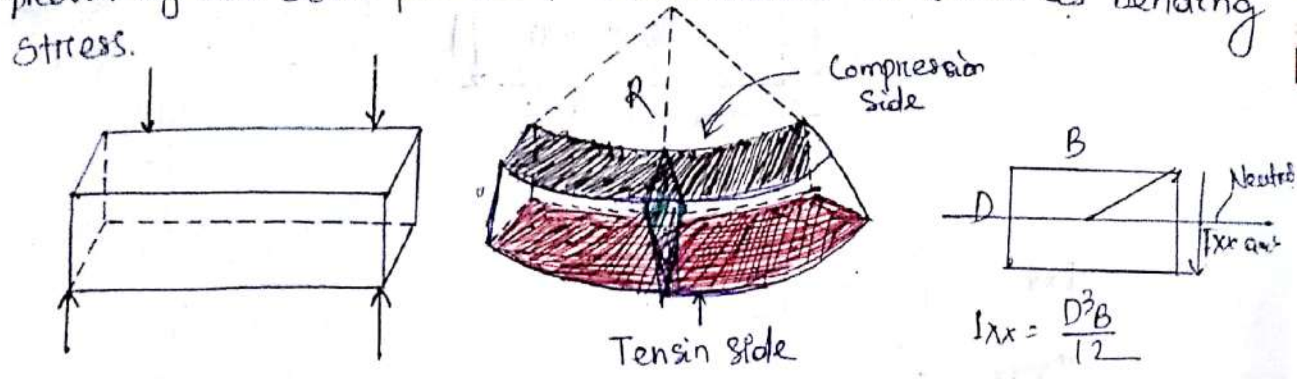
$$M_A = (14 \times 10) - 6(10-1) - 12(10 - 4.5) - 10(10-8)$$

$$= 140 - 54 - 66 - 20$$

$$= \boxed{0}$$

Bending Stress :- (δ_b)

When a beam is subject to moment then the internal resistance provid by the beam per unit cross section is known as bending stress.



(1) (II) (III)

Section Modulus (Z) :-

The ratio of (I/y) where, y is the farthes (maximum) point of the section from the neutral axis is called the section modules.

$$\boxed{Z = I/y_{max}}$$

2mark

State bending formula :-

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

Where, δ_b = bending stress

y = distance from the neutral axis

M = bending moment.

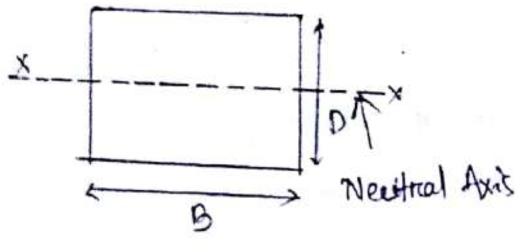
I = Moment of Inertia about neutral axis.

E = Youngs modulus of Elasticity.

R = Radius of curvature.

Section Modulus of some standard section :-

① Rectangle



$$I_{xx} = \frac{BD^3}{12}$$

$$Z = \frac{I_{xx}}{Y_{max}} = \frac{BD^3}{12} / \frac{D}{2} = \frac{BD^2}{6}$$

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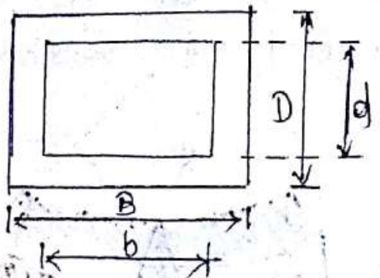
② Hollow Rectangle Section :-



$$I_{xx} = \frac{BD^3}{12} - \frac{bd^3}{12}$$

$$Y_{max} = \frac{D}{2}$$

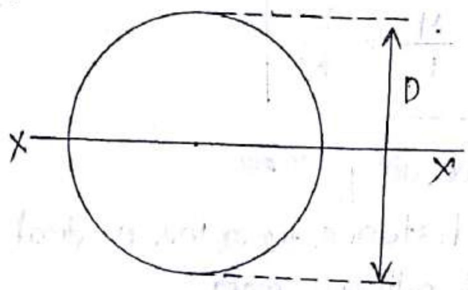
$$Z = \frac{I_{xx}}{Y_{max}}$$

$$= \frac{BD^3}{12} - \frac{bd^3}{12} \times \frac{2}{D}$$

$$= \frac{BD^3 - bd^3}{\cancel{12}\,6} \times \frac{\cancel{2}}{D}$$

$$= \frac{BD^3 - bd^3}{6D}$$

③ Circular Section :-



$$I_{xx} = \frac{\pi D^4}{64}$$

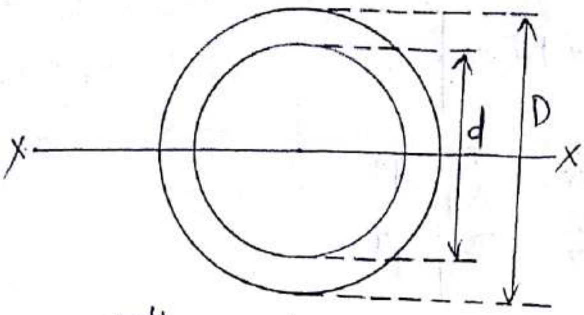
$$Y_{max} = \frac{D}{2}$$

$$Z = \frac{I_{xx}}{Y_{max}}$$

$$= \frac{\pi \cancel{D^4}\,D^3}{\cancel{64}\,32} \times \frac{\cancel{2}}{\cancel{D}}$$

$$= \frac{\pi D^3}{32}$$

(4) Hollow circular Section :-



$$I_{xx} = \frac{\pi D^4}{64} - \frac{\pi d^4}{64}$$

$$y_{max} = \frac{D}{2}$$

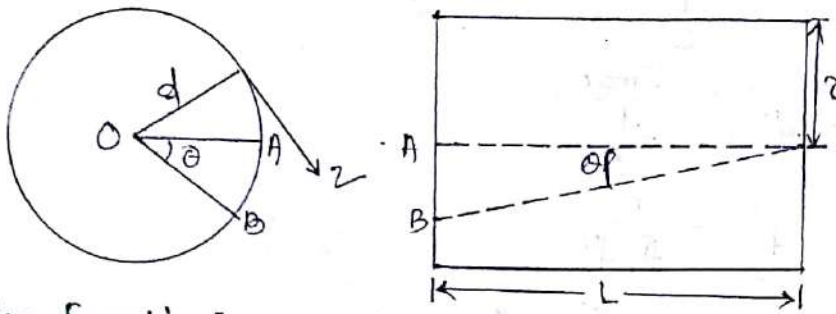
$$Z = \left(\frac{\pi D^4}{64} - \frac{\pi d^4}{64}\right) \Big/ \frac{D}{2}$$

$$= \frac{\pi D^4 - \pi d^4}{\cancel{64}} \times \frac{\cancel{2}}{D}$$

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

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

Torsion :-



Torsion Equation :-

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

$\boxed{\tau = \text{tau}}$

where, T = Torque in N/mm

J = Polar moment of inertia

r = Distance of any point from the centre of shaft on the transverse cross section.

G = Modulus of EGDT in N/mm^2

θ = Angle of twist in radial.

L = Length of the shaft

τ = Shear stress.

* Torsion is twisting of an object due to an applied torque.

Polare Moment of Inerefia (J) :-

$$\boxed{J = I_{xx} + I_{yy}}$$

Fore solid shafft $I_{xx} = \frac{\pi}{64} d^4$

$I_{yy} = \frac{\pi}{64} d^4$

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

forc. Hollow sharcft $I_{xx} = \left(\frac{\pi}{64}\right)(D^4 - d^4)$

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

Maximum Shear Stress (τ_{max})

When $r = \frac{d}{2}$

then $\tau = \tau_{max}$

$$\frac{T}{J} = \frac{\tau_{max}}{\frac{d}{2}}$$

$$\Rightarrow \frac{T}{\frac{\pi}{32} d^4} = \frac{\tau_{max}}{\frac{d}{2}}$$

$$\Rightarrow \frac{\tau_{max}}{\frac{d}{2}} = \frac{T}{\frac{\pi}{32} d^4}$$

$$\Rightarrow \tau_{max} = \frac{T \times \cancel{32}^{16}}{\pi \cancel{d^4}_{d^3}} \times \frac{\cancel{d}}{\cancel{2}}$$

$$\Rightarrow \tau_{max} = \boxed{\frac{16T}{\pi d^3}}$$

for hollow shear stress $r = \frac{D}{2}$

$$\frac{T}{J} = \frac{\tau_{max}}{\frac{D}{2}}$$

$$\Rightarrow \frac{T}{\frac{\pi}{32} d^4} = \frac{\tau_{max}}{D/2}$$

$$\Rightarrow \tau_{max} = \frac{\cancel{32}^{16} T}{\pi d^4} \times \frac{D}{\cancel{2}}$$

$$= \boxed{\frac{16D}{\pi d^4}}$$

Formula

$$P = \frac{2\pi NT}{60}$$

where,

T = Torcque

N = revolution/min

Problem-1

A hollow steel shaft transmit 200 KW of power at 150 RPM. The total angle of twist in a length of 5 meter of the shaft is 3°. Find the inner & outer diameter of the shaft if the permissible shear stress is 60M Pascal (N/mm²), G = 80 GPascal.

Solution:-

Given data-

$P = 200\ KW = 200\times10^3 = 2\times10^5$ watt.

$N = 150$ RPM

$L = 5$ meter $= 5000$ mm

$\theta = 3^\circ = 3\times\frac{\pi}{60} = 0.05$ radian

$\tau_{max} = 60\ mPa = 60 N/mm^2$

$G = 80\ GPa = 80\times10^3 N/mm^2$

We know, $P = \frac{2\pi NT}{60}$

$\Rightarrow 2\times10^5 = \frac{2\times\pi\times150\times T}{60}$

$\Rightarrow T = \boxed{12732.39\times10^3}$

Again, $\frac{T}{J} = \frac{\tau_{max}}{r}$

$\Rightarrow \tau_{max} = \frac{T\times\cancel{32}^{16}}{\pi(D^4-d^4)}\times\frac{D}{\cancel{2}}$

$\Rightarrow \tau_{max} = \frac{16TD}{\pi(D^4-d^4)}$

$\Rightarrow 60 = \frac{16\times12732.39\times10^3\times D}{\pi(D^4-d^4)}$

$\Rightarrow (D^4-d^4) = \frac{16\times12732.39\times10^3\times D}{\pi 60}$

$\Rightarrow (D^4-d^4) = 1018591.64D$ —— (1)

Again $\frac{\tau_{max}}{D/2} = \frac{G\theta}{L}$

$\Rightarrow \frac{60}{D/2} = \frac{80\times10^3\times0.05}{5000}$ $\Rightarrow D = 144.23$ mm.

~~$\Rightarrow D = \frac{80\times10^3\times0.05\times2}{5000\times60} = 144.23$ mm.~~

Putting the value of D is eqⁿ ①

$$\boxed{d = 130.02mm}$$

Unit-3

{ FLUID MECHANICS }

21/07/18

Introduction:-

Liquid + Gas = Fluid.

→ It is a substance which has the tendency to flow under the application of extremly small amount of shear force.

Properties of the Fluid

① Mass Density (ρ)

→ It is the mass of the fluid per unit volume.

→ Density of the fluid decreases with increase in temperature & vice versa.

→ Units - S.I. = Kg/m^3
C.G.S = g/cm^3

→ Density of the water = 1000 Kg/m^3

② Specific volume (ν)

→ It is the volume of the fluid per unit mass.

→ Units - SI = m^3/Kg
CGS = Cm^3/g

$$\nu = \frac{volume}{mass}$$

$$\boxed{\nu = \frac{1}{\rho}}$$

③ Weight Density or Specific weight :- (w)

→ It is the ratio between weight of the fluid & volume.

Mathematically, $w = \frac{W}{V}$

$$w = \frac{mg}{(m/\rho)}$$

$$\boxed{w = \rho g}$$

$$\boxed{1 lt = 10^{-3} m^3}$$

Units :-

$SI = N/m^3$

$CGS = dyne/cm^3$

④ Specific Gravity (S) :-

→ It is the ratio between weight density on any fluid to the weight density of standard fluid.

Mathematically, $\boxed{S = \dfrac{\text{weight density of any fluid}}{\text{weight density of standard fluid}}}$

For liquid, $S = \dfrac{\text{weight density of any liquid}}{\text{water}}$

$= \dfrac{\rho \text{ of liquid} \times \cancel{g}}{\rho \text{ of water} \times \cancel{g}}$

$= \dfrac{\rho \text{ of liquid}}{\rho \text{ of water}}$

For gas, $S = \dfrac{\rho_{gas}}{\rho_{air}}$

⑤ Temperature :-

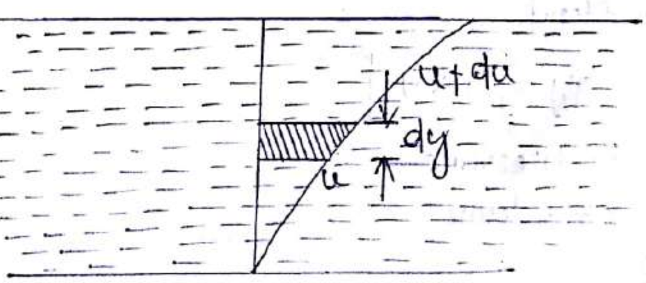
→ It is the property of the fluid which indicates the degree of hotness & coolness of fluid.

⑥ Pressure :-

→ It is the force per unit area of the fluid such that the area will be perpendicular to the direction of applied force.

Imp ⑦ Viscosity (μ) :-

→ It is the property of fluid due to which it provide the resistance to the flow of 1 layer of the fluid over another adjacent layer.



Date - 27/08/18

→ According to Neutons law of viscocity, change in velocity gradient.

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

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

$$\Rightarrow \boxed{\mu = \tau \frac{dy}{du}} \quad NS/m^2$$

→ Units :-

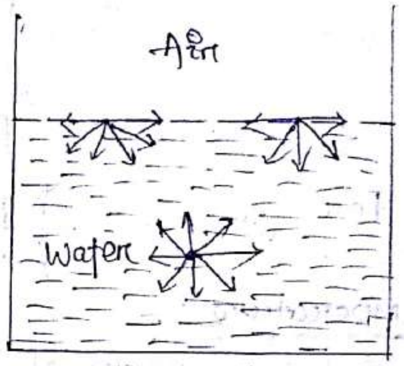
In SI units = NS/m^2

C.G.S. Units = $dyne.s/cm^2$ (Poise)

Surface Tension :-

→ It is the tensile force acting on the surface between the two immissible fluid.

$$\Rightarrow \boxed{Y = \frac{f}{d}}$$



Where Y = Surface tension

f = Force applied on the liquid

d = Length where the force acts

→ Units :-

N/m

Energy of the fluid :-

→ Generally there are three types of fluid energy which are included in fluid mechanics.

I) Pressure energy

II) Potential energy

III) Kinetic energy.

I) Pressure Energy :-

→ It is the energy posses by the fluid due to pressure acting on the fluid.

→ Pressure energy = $\boxed{P \times V}$

P = Pressure

V = Volume

ii) Potential Energy (PE) :-

→ It is the energy posses by the fluid due to it's hight from the datum plane.

→ Potential energy = $\boxed{mgh}$

iii) Kinetic Energy (KE) :-

→ It is the energy posses by the fluid due to its motion.

→ Kinetic Energy = $\boxed{\frac{1}{2}mv^2}$ m = mass
v = velocity.

ENERGY HEAD :-

→ The energy of the fluid per unit weight is known as energy head.

→ It is represented in meter scale.

PRESSURE HEAD :-

→ It is the pressure energy per unit weight of the fluid.

→ Pressure Head $= \frac{P.V}{mg}$

$$= \frac{P}{(mg/V)} = \frac{P}{(W/V)} = \boxed{\frac{P}{\rho g}}$$

POTENTIAL HEAD :-

→ It is the potential energy per unit weight of the fluid.

→ Potential Head $= \frac{\cancel{Mg}h}{\cancel{mg}} = \boxed{h}$

KINETIC HEAD :-

→ It is the kinetic energy per unit weight of the fluid.

$$\text{Kinetic Head} = \frac{\frac{1}{2}\cancel{m}v^2}{\cancel{m}g} = \boxed{\frac{v^2}{2g}}$$

* Total Head of the fluid = Pressure Head + Potential Head + Kinetic Head.

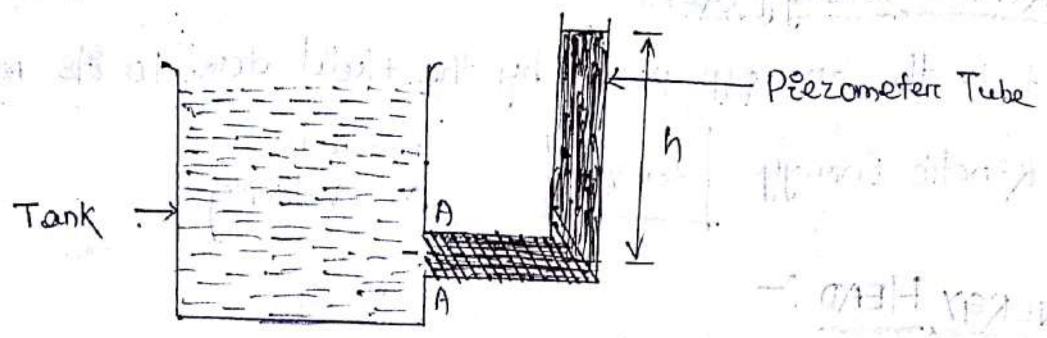
$$\boxed{\text{Total Head} = \frac{P}{\rho g} + h + \frac{v^2}{2g}}$$

28/08/18

Pressure Measuring Device :-

I) Piezometer Tube :-

→ It consist of a glass tube which one end is connected to the point at which pressure is to be measure & other end is opened to the atmosphere.



→ The height which is raised in the tube is used to calculate the pressure.

i.e. - $\boxed{P = \rho g h}$

→ It used to measure the positive pressure.

Steady flow :-

→ It is the flow of fluid is said to be steady if it's properties at any point doesn't change w.r.t. time.

Incompressible flow :-

→ If the density of the fluid remain constant through out its flow then the flow is said to be Incompressible flow.

i.e. - ρ = constant.

Rate of flow or discharge :- ($\dot{Q}$)

→ It is defined as the quantity of fluid flowing per second.

→ For liquid it is volume per second & for gas it is weight/sec.

$$\dot{Q} = \frac{\text{Volume}}{\text{second}} \quad m^3/s \quad (\text{for liquid})$$

$$= \frac{\text{Weight}}{\text{sec}} \quad \text{kgf or N/sec} \quad (\text{For gas})$$

→ $\dot{Q} = \frac{V}{t} = \frac{A.l}{t} = \boxed{A.V}$

A = Area
V = Velocity

✱ Mass flow rate = $(\dot{M}) = \frac{m}{t} = \frac{\rho V}{t} = \boxed{\rho A.V}$

Vgmp

* State & Explain Continuity Equation :-

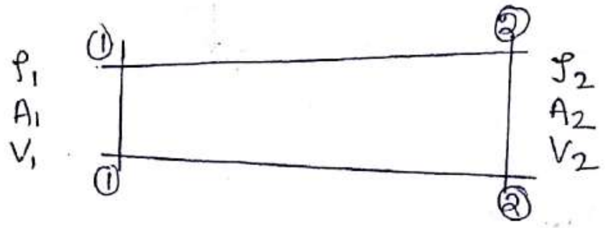
Statement :-

→ The Fluid flowing through the pipe at all the cross-section the quantity of the fluid per second remain constant.

→ It is best on the low of conservation of mass.

Explanation :-

Consider two cross-section of a pipe through which liquid flow as shown in the figure.



Let,

V_1 = Avarcage velocity of fluid at section 1-1

A_1 = Area of pipe at section 1-1

ρ_1 = Density of section 1-1

And V_2, A_2 & ρ_2 = corresponding value at section 2-2

→ mass flow rate at section 1-1 = $\boxed{\rho_1 A_1 V_1}$

→ mass flow rate at section 2-2 = $\boxed{\rho_2 A_2 V_2}$

→ According to the Low of conservation of mass

mass flow rate at section 1-1 = mass flow rate at section 2-2

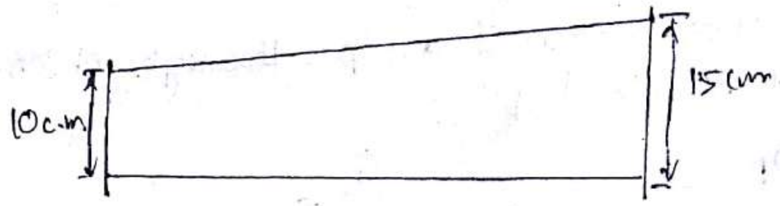
$$\Rightarrow \boxed{\rho_1 A_1 V_1 = \rho_2 A_2 V_2}$$

for incompressible flow, $\boxed{A_1 V_1 = A_2 V_2}$ [∵ density = constant

Problem-1

Two diameters of a pipe at the section ① & ② are 10 cm & 15 cm respectively. Find the discharge through the pipe if the velocity of the water flowing through the pipe at section ① is 5 m/sec. Determine the velocity at section ②.

Solution:-



given data:-

$V_1 = 5 \text{ m/sec}$

$V_2 = ?$

$d_1 = 10 \text{ c.m.} = \frac{10}{100} = 0.1 \text{ m.}$

$d_2 = 15 \text{ cm.} = \frac{15}{100} = 0.15 \text{ m.}$

$A_1 = \frac{\pi}{4} d_1^2 = \frac{\pi}{4} \times (0.1)^2 = 0.00785 \text{ m}^2$

$A_2 = \frac{\pi}{4} d_2^2 = \frac{\pi}{4} \times (0.15)^2 = 0.01767 \text{ m}^2$

i) Discharge through the pipe

$\dot{Q} = A_1 V_1$

$= 0.00785 \times 5 = 0.0392 \text{ m}^3/\text{s}$

ii) According to eqn of continuity

$A_1 V_1 = A_2 V_2$

$\Rightarrow 0.0392 = 0.01767 \times V_2$

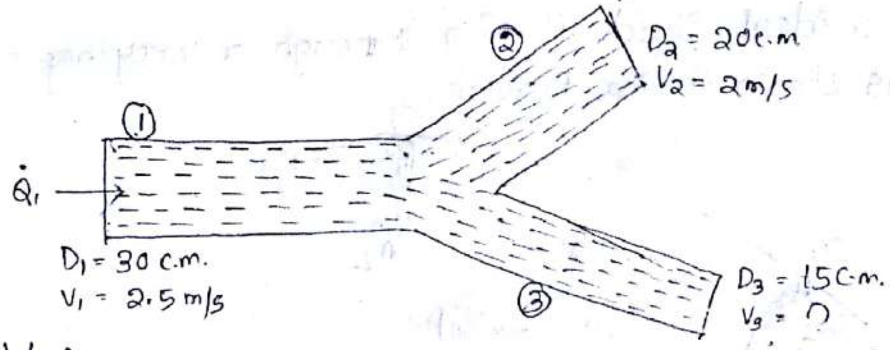
$\Rightarrow V_2 = \frac{0.0392}{0.01767}$

$= \boxed{2.218 \text{ m/sec.}}$ (Ans)

Problem-2

A 30 c.m. diameters of pipe, carrying water, branches into two pipes of diameter 20 c.m. & 15 c.m. respectively. If the average velocity in the 30 c.m. diameter pipe is 2.5 m/s. Find the discharge in this pipe. Also determine the velocity in 15 cm. pipe if the average velocity in 20 c.m. diameter pipe is 2m/sec.

Solution:-



given data:-

In section ①

$D_1 = 30 \text{ c.m.} = \frac{30}{100} = 0.3 \text{ m}$

$A_1 = \frac{\pi}{4} D_1^2 = \frac{\pi}{4} \times 0.3^2 = \boxed{0.07068 \text{ m}^2}$

$V_1 = 2.5 \text{ m/s}$

In section ②

$D_2 = 20 \text{ c.m.} = \frac{20}{100} = 0.2 \text{m}.$

$A_2 = \frac{\pi}{4} (D_2)^2 = \frac{\pi}{4} (0.2)^2 = \boxed{0.03141 \text{ m}^2}$

$V_2 = 2 \text{ m/s}$

In section ③

$D_3 = 15 \text{ c.m.} = \frac{15}{100} = 0.15 \text{ m}^2$

$A_3 = \frac{\pi}{4} (D_3)^2 = \frac{\pi}{4} \times (0.15)^2 = \boxed{0.0176 \text{ m}^2}$

① Discharge through section (1)

$\dot{Q}_1 = A_1 V_1$

$= 0.07068 \times 2.5$

$= \boxed{0.1767 \text{ m}^3/\text{sec}}$. (Ans)

② Velocity at section-3 :

$\dot{Q}_1 = Q_2 + Q_3$

$\Rightarrow A_1 V_1 = A_2 V_2 + A_3 V_3$

$\Rightarrow V_3 = \frac{A_1 V_1 - A_2 V_2}{A_3}$

$\Rightarrow V_3 = \frac{0.1767 - 0.3141 \times 2}{0.0176} = \boxed{6.44 \text{ m/s}}$ (Ans)

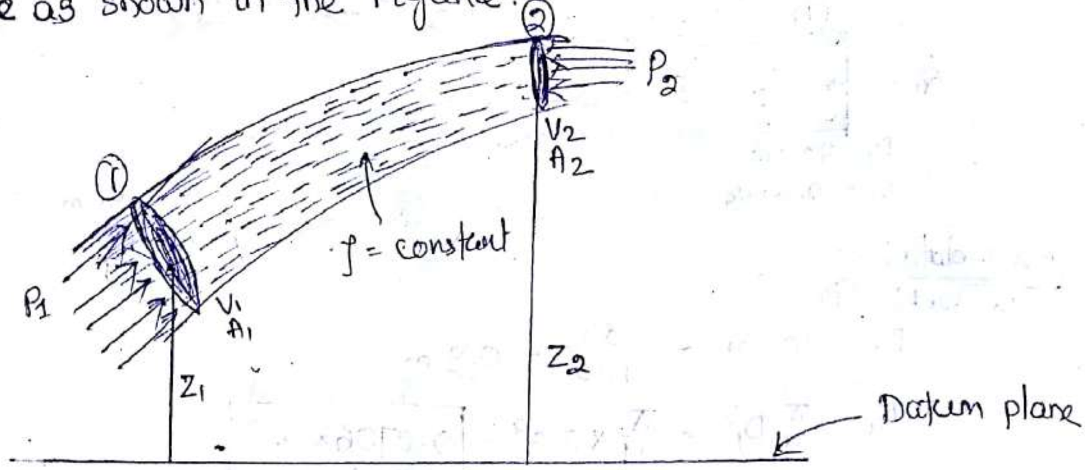
* State & Explain Bernoullis Theorem :-

Statement :-

For a steady, non-viscous & incompressible flow of fluid to total energy at any point remain constant.

Proof :-

Consider a ideal fluid flowing through a varying cross section of pipe as shown in the figure.



Let, P_1 = Pressure at the section-1

A_1 = Area

V_1 = Average velocity of the fluid at section-1

Z_1 = Height of the fluid element at section-1-1 From the datum plane.

→ P_2, A_2, V_2 & Z_2 = Corresponding value of fluid element at section

→ According to continuity equation,

$$A_1V_1 = A_2V_2 \quad \text{——— (1)}$$

Workdone change in pressure $= \boxed{(P_1 - P_2) \times V}$ ——— (2)

Change in potential energy due to height,

$$\Delta PE = mgZ_2 - mgZ_1$$

$$\Rightarrow \boxed{\Delta PE = mg(Z_2 - Z_1)} \quad \text{——— (3)}$$

Change in kinetic energy, $\Delta KE = \boxed{\frac{1}{2}m(V_2^2 - V_1^2)}$ ——— (4)

According to work energy principle,

Net work done = Change in ΔPE − change in ΔKE

$$\Rightarrow \boxed{(P_1 - P_2) = mg(Z_2 - Z_1) + \frac{1}{2}m(V_2^2 - V_1^2)} \quad \text{——— (5)}$$

$$\Rightarrow (P_1 - P_2) = \frac{mg(Z_2 - Z_1)}{V} + \frac{\frac{1}{2} m (V_2^2 - V_1^2)}{V}$$

$$\Rightarrow (P_1 - P_2) = \rho g (Z_2 - Z_1) + \frac{1}{2} \rho (V_2^2 - V_1^2)$$

devide ρg in both side

$$\Rightarrow \frac{(P_1 - P_2)}{\rho g} = \frac{(Z_2 - Z_1) + \frac{1}{2}(V_2^2 - V_1^2)}{g}$$

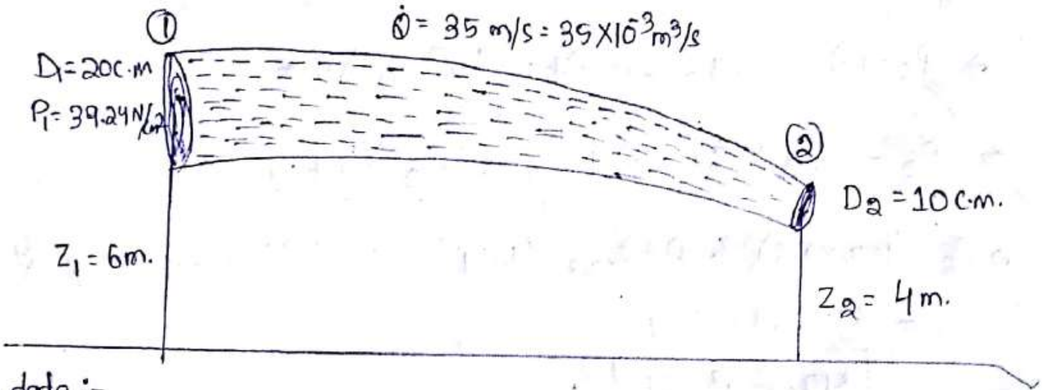
$$\Rightarrow \boxed{\frac{P_1}{\rho g} + Z_1 + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + Z_2 + \frac{V_2^2}{2g}}$$

i.e. $\frac{P}{\rho g} + Z + \frac{V^2}{2g} = \text{constant}$ (Proved)

Problem-No-3

The water is flowing through a pipe having diameter 20 c.m. & 10 c.m. at section ① & ② respectively. The rate of flow through pipe is 35m/sec. The section① is 6m. above the dactum & section ② is 4m above dactum. If the pressure at section① is $39.24 N/cm^2$. Find the intensity of pressure at section ②.

Solution



Given data :-

At section-1

$D_1 = 20 \text{ c.m.} = \frac{20}{100} = 0.2m$

$A_1 = \frac{\pi}{4}(D)^2 = \frac{\pi}{4} \times (0.2)^2 = \boxed{0.0314 m^2}$

$P_1 = 39.24 \ N/cm^2 = 39.24 \times 10^4 \ N/m^2$

$Z_1 = 6m$

At section-2

$D_2 = 10 \text{ c.m} = 0.1 \text{ c.m.}$

$A_2 = \frac{\pi}{4}(D_2)^2 = \frac{\pi}{4}(0.1)^2 = \boxed{0.00785 m^2}$

$Z_2 = 4 m.$

& $Q = 35 m/s = 35 \times 10^{-3} m^3/s$

$\therefore \boxed{Q = A_1 V_1 = A_2 V_2}$

$\Rightarrow 35 \times 10^{-3} = 0.0314 \times V_1$

$\Rightarrow V_1 = \frac{35 \times 10^{-3}}{0.0314} = \boxed{1.1146 \ m/s}$

Again $Q = A_2 V_2$

$\Rightarrow 35 \times 10^{-3} = 0.00785 \times V_2$

$\Rightarrow V_2 = \frac{35 \times 10^{-3}}{0.00785} = \boxed{4.458 \ m/s}$

According to Bernoulli's equation,

$$\boxed{\frac{P_1}{\rho g} + Z_1 + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + Z_2 + \frac{V_2^2}{2g}}$$

$\Rightarrow \frac{P_2}{\rho g} + Z_2 + \frac{V_2^2}{2g} = \frac{P_1}{\rho g} + Z_1 + \frac{V_1^2}{2g}$

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

$\Rightarrow \frac{1}{\rho g}(P_2 - P_1) = (Z_1 - Z_2) + \frac{1}{2g}(V_1^2 - V_2^2)$

$\Rightarrow (P_2 - P_1) = \rho g \{(Z_1 - Z_2) + \frac{1}{2g}(V_1^2 - V_2^2)\}$

$\Rightarrow P_2 = \rho g \{(Z_1 - Z_2) + \frac{1}{2g}(V_1^2 - V_2^2)\} + P_1$

$\Rightarrow P_2 = (1000 \times 9.8)\{(6-4) + \frac{1}{2 \times 9.8}((1.114)^2 - (4.458)^2)\} + 39.24 \times 10^4$

$= 402683.614$

$= \boxed{40.2683 \times 10^4 \ m^3 s}$ (Ans)

Complete

03.09.18

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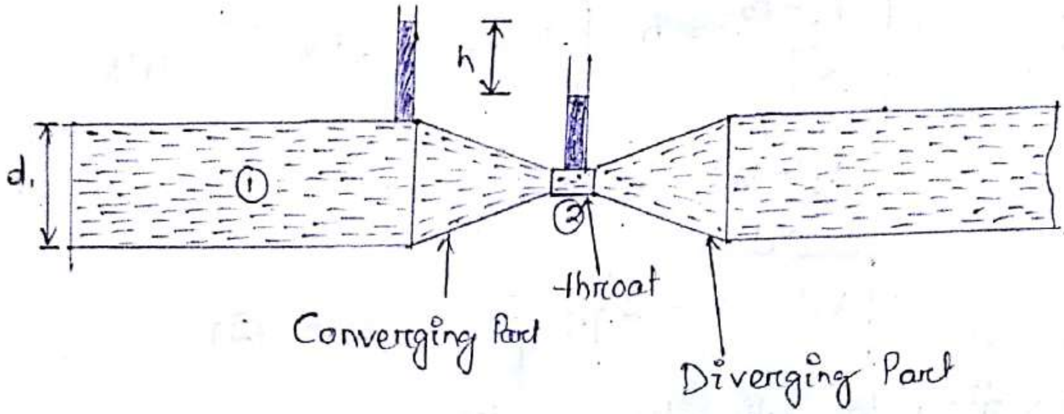
APPLICATION OF BERNOULLI'S THEOREM :-

① Venturimeter.
② Orifice meter
③ Pitot tube

① Venturimeter :-

→ It is a device which is use to measure the rate of flow of the fluid flowing through the pipe.



It consist of 3 parts -

I) Converging
II) Diverging
III) Throat.

→ When fluid flowing through converging part the pressure will gradually decrease & velocity gradually increase.
At the throat both pressure & velocity remains constant.
While moving through the diverging part again the pressure ~~start~~ start to increase & velocity decrease gradually.

Principle

→ It watches on the principle of Bernoulli's theorem. i.e. the energy of an ideal fluid flowing through a pipe remain constant at any point.

Let, P_1 = Pressure at section ①
V_1 = Velocity at section ①
Z_1 = height of the section① from the datum plane
A_1 = Area at section ①

Let P_2, V_2, Z_2 & A_2 = Corresponding value at section ②

→ By Applying Bernoulli's theorem at section ① & ②

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + \cancel{Z_1} = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + \cancel{Z_2}$$

$$\Rightarrow \frac{P_1}{\rho g} + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} \qquad [\because Z_1 = Z_2]$$

$$\Rightarrow \frac{P_1}{\rho g} - \frac{P_2}{\rho g} = V$$

$$\Rightarrow \boxed{\frac{P_1 - P_2}{\rho g} = h} \text{ ——— (1)}$$

$$\frac{V_2^2 - V_1^2}{2g} = h$$

$$\Rightarrow \boxed{V_2^2 - V_1^2 = 2gh} \text{ ——— (2)}$$

According to continuity equation.

$$A_1 V_1 = A_2 V_2$$

$$\Rightarrow \boxed{V_1 = \frac{A_2 V_2}{A_1}} \text{ ——— (3)}$$

Putting the value of eqⁿ ③ into eqⁿ ②

$$V_2^2 - \left(\frac{A_2 V_2}{A_1}\right)^2 = 2gh$$

$$\Rightarrow V_2^2 \left(1 - \frac{A_2^2}{A_1^2}\right) = 2gh$$

$$\Rightarrow V_2^2 = \frac{2gh}{\left(1 - \frac{A_2^2}{A_1^2}\right)}$$

$$\Rightarrow V_2^2 = \frac{2gh\, A_1^2}{A_1^2 - A_2^2}$$

$$\Rightarrow V_2 = \frac{A_1 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$$

Now discharge given by

$$Q = A_2 V_2$$

$$\boxed{Q_{th} = A_2 V_2 = \frac{A_1 A_2 \sqrt{2gh}}{A_1^2 - A_2^2}}$$

This is the theoretical discharge

Now the actual discharge is given by

$$\boxed{Q_{act} = C_d \frac{A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}}$$

where C_d = Co-efficient of discharge.

Problem

A horizontal venturimeter with inlet & throat diameter 30 c.m. & 15 c.m. respectively is used to measure the flow of the water. The reading of different monometer connected to the inlet & throat is 27m of mercury. Determine the rate of flow.

Take $C_d = 0.98$.

formula

$h = x\left(\frac{S_h}{S_l} - 1\right)$

for lite liquid

$h = x\left(1 - \frac{S_l}{S_h}\right)$

for heavy liquid

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Orifices :-

→ It is a small opening of any cross-section on the side or at the bottom of a tank.

Classify Orifices :-

(A) According to Cross-section Area

1. Circular orifices
2. Triangular orifices
3. Rectangular orifices
4. Square orifices

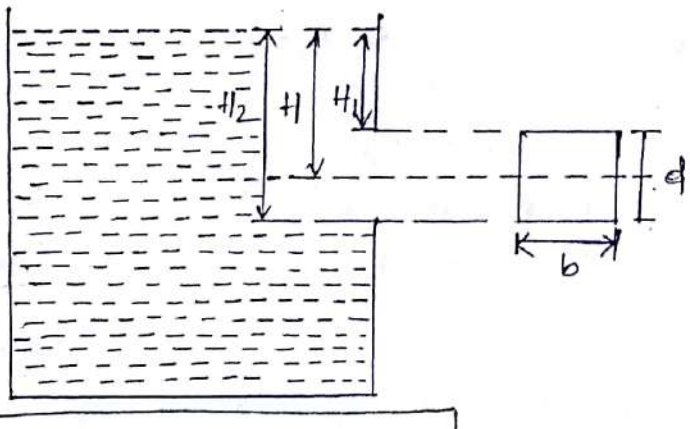
(B) According to shape of upstream edge of orifices

1. Sharp edge orifices
2. Bell mouthed orifices.

(C) According to nature of discharge

1. Free discharge orifices
2. Sub-merged orifices

Discharge through rectangular orifices



Formula

$$\boxed{Q = \frac{2}{3} C_d \cdot b\sqrt{2g}\left(H_2^{3/2} - H_1^{3/2}\right)}$$

where, C_d = Coefficient of discharge

b = bredth of orifice

H_1 = Height of liquid above top edge of orifices

H_2 = Height of liquid above bottom edge of orifices

d = depth of orifice ie. $(H_2 - H_1)$

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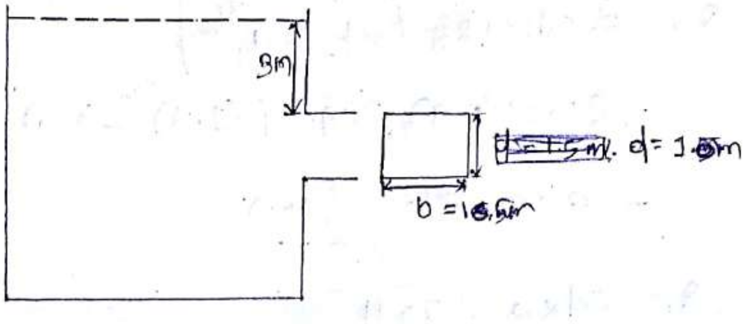
Problem-1

A rectangulare orifices, 1.0m wide (breadth) & 1.5m deep is discharging water from a tank. If the water level in the tank is 3 m. above the top edge of the orifices. Find the discharge through the orifices.

Take the coefficient of discharge for the orifice = 0.6

Solution



given data

$d = 1.5m$

$H_1 = 3\ m.$

$Cd = 0.6$

$g = 9.8$

$\therefore H_2 = 3 + 1.5 = 4.5\ m.$

$$\therefore Q = \frac{2}{3} Cd \cdot b\sqrt{2g}\left(H_2^{3/2} - H_1^{3/2}\right)$$

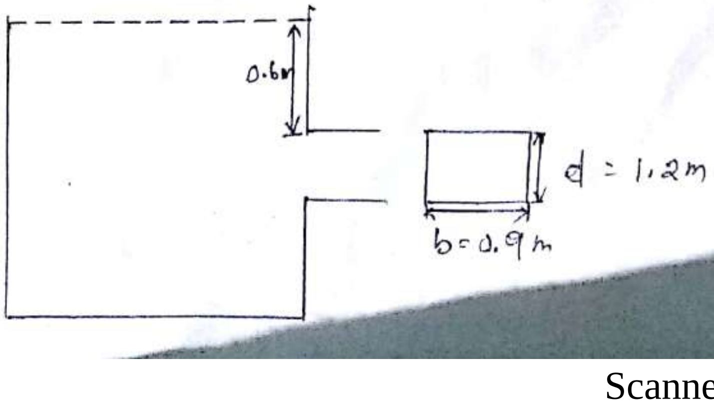
$$= \frac{2}{3} \times (0.6)\ 1\left(\sqrt{2 \cdot 9.8}\right)\left[(4.5)^{\frac{3}{2}} - (3)^{3/2}\right]$$

$$= 7.7\ m^3/s$$

Problem-2

A rectangulare orifices 0.9m wide & 1.2m deep is discharging water from a vessel the top edge of the orifices 0.6M below the water surface in the vessel. Calculate the discharge through the orifices if Cd = 0.6 & percentage of error if the orifices is treated as a small orifices.

Solution



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given data

$b = 0.9\,m$

$d = 1.2\,m$

$H_1 = 0.6\,m$

$H_2 = H_1 + d = 1.2 + 0.6 = 1.8\,m$

$Cd = 0.6$

$g = 9.8$

$$\therefore Q = \frac{2}{3} cd\, b\sqrt{2g}\left[H_2^{3/2} - H_1^{3/2}\right]$$

$$= \frac{2}{3}(0.6)(0.9)\sqrt{2\times 9.8}\left[(1.8)^{3/2} - (0.6)^{3/2}\right]$$

$$= 3.108\ m^3/s \quad \text{(Ans)}$$

$$Q_1 = Cd \times a \times \sqrt{2gH}$$

$$= 0.6 \times 1.08 \times \sqrt{2\times 9.8 \times 1.2}$$

$$= 3.142$$

$$\% = \frac{3.142 - 3.108}{3.108} \times 100 = 1.09\ \% \quad \text{(Ans)}$$

NOTCHES :-

dt-20-09-2018

→ It is a device which is used to measure the rate of flow of liquid through a small channel.

→ It is also defined as an opening in the side of a tank or a small channel in such a way that the liquid surface in the tank or channel is below the top edge of the opening.

Types of Notches :-

According to the shape of the opening -

i) Rectangular Notch
ii) Triangular Notch
iii) Trapezodial Notch
iv) Stepped Notch

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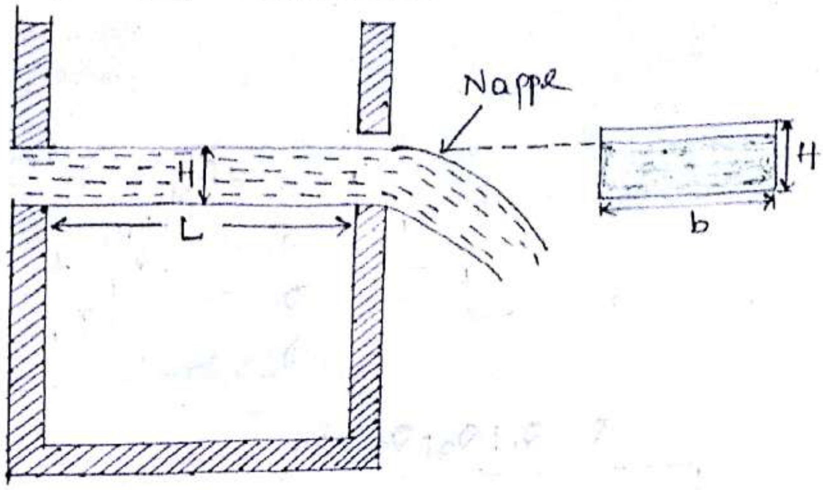
Discharge over a Rectangular Notches :-

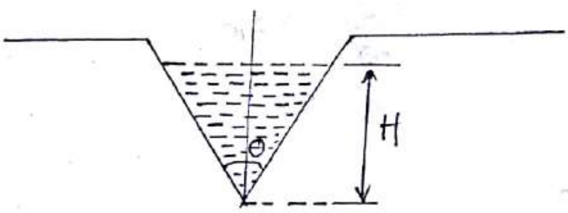


$$\boxed{Q = \frac{2}{3} \cdot Cd\, L\sqrt{2g}\,(H)^{3/2}}$$

Where,
Cd = coefficient of discharge
L = Length of Notches
H = Head of water over the creast.

IMP

Discharge over a triangular Notches :-



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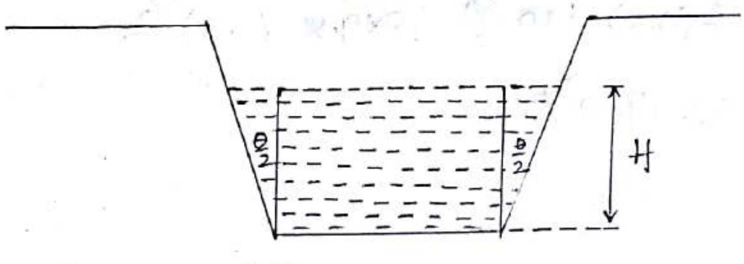
$$\boxed{Q = \frac{8}{15}\, Cd \tan\theta \sqrt{2g}\,(H)^{5/2}}$$

Discharge over a trapizoidal Notches :-

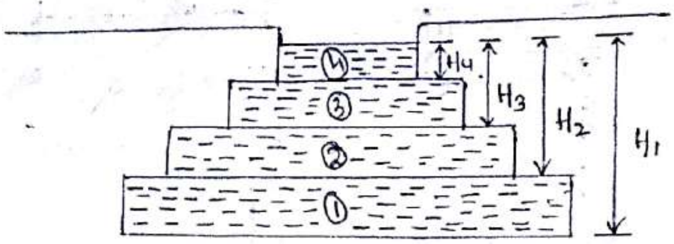


Q = Q rect + Q triangular.

$$\boxed{Q = \frac{2}{3} Cd\, L\sqrt{2g}\,(H)^{3/2} + \frac{8}{15}\, Cd_1 \tan\frac{\theta}{2} \times \sqrt{2g}\,(H)^{5/2}}$$

Where, Cd = Coefficient of discharge for rectangular notches.
Cd_1 = Coefficient of discharge for triangular ~~for~~ Notches.

Stepped Notches:-



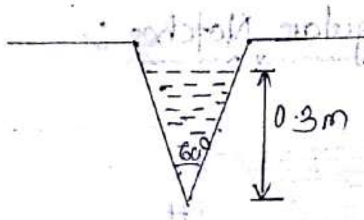
$$Q = Q_1 + Q_2 + Q_3 + Q_4$$

$$\boxed{Q = \frac{2}{3} C_d L \sqrt{2g}\, (H_1)^{3/2} + \frac{2}{3} C_d L_2 \sqrt{2g}\, (H)^{3/2} \ldots}$$

Problem-1

Find the discharge over a triangular notch angle 60°. When the head over the V-notch is 0.3 m. (Assume $C_d = 0.6$)

Solution



Given data:-

$\theta = 60^\circ$

$H = 0.3\text{m}$

$C_d = 0.6$

$$\therefore Q = \frac{8}{15} C_d \tan\frac{\theta}{2} \sqrt{2g}\, (H)^{5/2}$$

$$= \frac{8}{15}(0.6) \tan\frac{60^\circ}{2} \sqrt{2 \times 9.8}\, (0.3)^{5/2}$$

$$= 0.04 \ m^3/s$$

Date- 25/09/2018

Flow through Pipes :-

LOSS OF ENERGY IN PIPES :-

→ When a fluid is flowing through a pipe, the fluid experience some resistance due to which some of the energy of fluid is Loss.

Energy Losses

Major
- → Due to friction
  - a) Darcy-Weisbach
  - b) Chezy's formula

Minor
- → Due to i) bending
  - ii) Fitting
  - iii) Sudden expansion of pipe
  - iv) Sudden constraction of pipe.

IMP

a) Darcy-Weisbach Formula :-

→ The loss of head in pipe due to friction is calculated from Darcy-weisbach equation as follows.

$$\boxed{hf = \frac{4fLV^2}{2g}}$$

Where, hf = Loss of head due to friction
f = coefficient of friction
L = Length of the pipe
V = velocity of the liquid flowing through the pipe
d = diameter of pipe.

Hydraulics Gradient & total energy line :-

Hydraulic Gradient Line

→ It is defined as the line which gives the sum of pressure head ($\frac{p}{\rho g}$) & potential head (z) of a flowing fluid in a pipe with respect to some reference line.

→ Hydraulic Gradient line = pressure head + Potential head

$$= \boxed{\frac{p}{\rho g} + z}$$

Total Energy Line

→ It is defined as the line which gives the sum of pressure head $\left(\frac{P}{\rho g}\right)$, Potential head (z) & kinetic head $\left(\frac{v^2}{2g}\right)$ of a flowing fluid in a pipe with respect to some reference line.

→ Total Energy line = Pressure head + Potential head + Kinetic head

$$= \boxed{\frac{P}{\rho g} + z + \frac{v^2}{2g}}$$

Engineering mechanics

→ Static (Rest) [study on the external effect of the rigid body under the application of different force]
→ Dynamic (moving)
→ Mechanics of material

Rigid body

A body is said to be rigid body if it will not under the internal differmation under the application of external load.

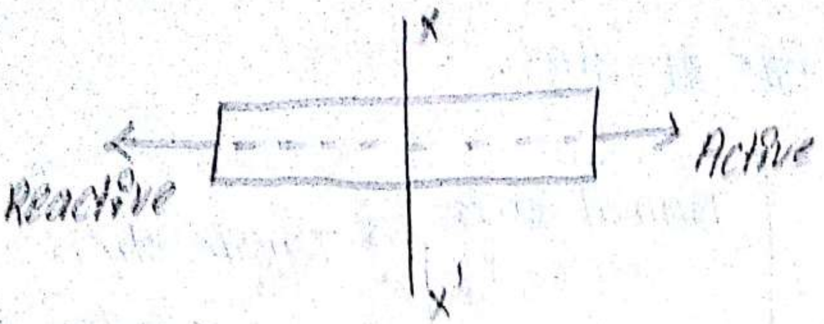
Mechanics of material

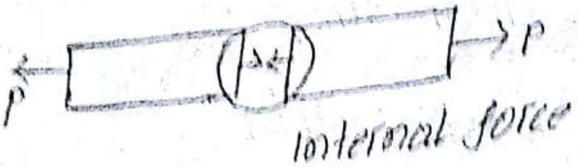
In mechanics of material we are dealing with the internal effect & differmation of body under the application of external force.

Type of force

1. Body force [Gravitational force, magnetic force, Inertia force]

2. Surface force
3. Internal force





* Stress

When a body is subjected to external force then the resisting force per unit area of cross section supply by the body to oppose the external force in order to keep the body in equilibrium is known as stress.

unit $(\sigma) = Nm^{-2}$
$= 1\ Pa$

$\sigma = 1N/mm^2$
$= 1N/(10^{-3})^2 m^2$
$= 10^6\ N/m^2$
$= MPa$

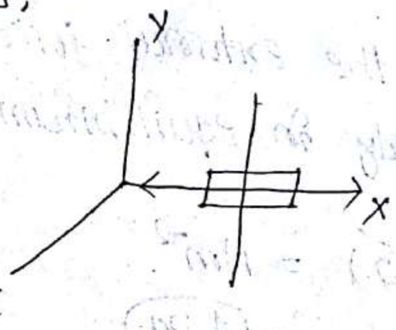
$1\ MPa = 10^6$
$1\ GPa = 10^9$

Type of stress

- Normal stress
  - Tensile stress
  - compressive stress
- Shear stress
- Bending stress
- Torsional stress

Normal Stress

If the stress acting $\perp^{rl}$ to the cutting section then that stress is known as normal stress.



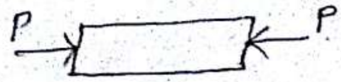
(i) **Tensile stress**

It is the stress included in a member or body due to application of axial pull.

(Length >>, Area <<)

(ii) **Compressive stress**

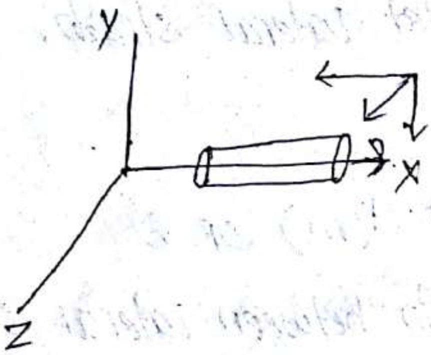
It is the stress included in the body due to application of axial push.



(Length <<, Area >>)

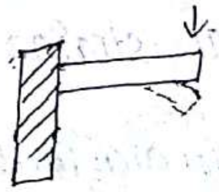
Shear stress

It is the stress include in a body due to application of $\parallel^{el}$ force to a cutting section.



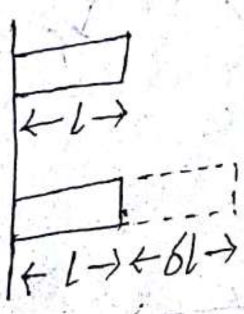
(S.S)

Bending stress



* **Strain (e)**

It is the ratio beteen change in dimension of a body to the original dimension of a body.



Mathematically, $e = \dfrac{\text{change in dimension}}{\text{original dimension}}$

$$= \frac{(l + \delta l) - l}{l} = \frac{\delta l}{l}$$

Linear strain

The strain occur along the application of load.

Lateral strain

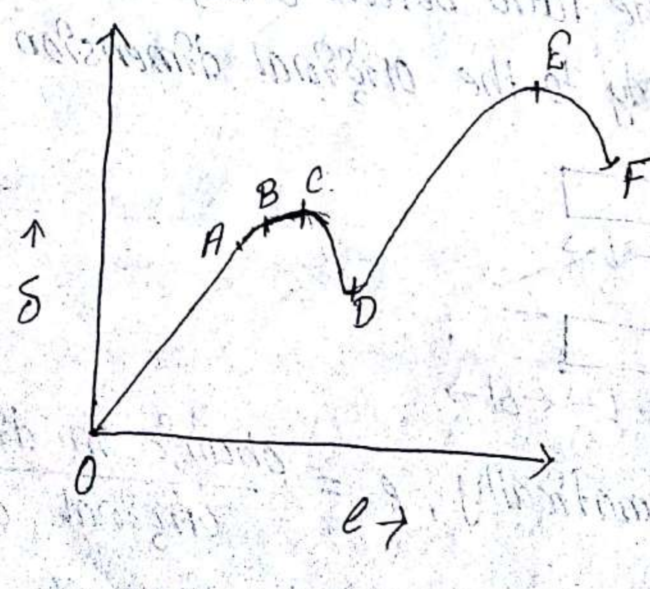
The strain perpendicular to the application of load is called lateral strain.

* Possition Ratio (1/m) or μ

It is the ratio between lateral strain to the linear strain.

* Stress - strain diagram for ductile material

Imp



Here,

OA = propotionality limit
AB = Elastic limit
C = Upper yield limit
D = lower yield limit
E = Ultimate point
F = Fracture point

From OA (propotionality region)

In this region the stress is directly propotionality to strain.

$\sigma \propto e$

From AB (Elastic region)

→ In this region the body will behave the property of elasticity. The point B is the elastic limit.

→ In this region the strain increase slightly more than stress.

From CD (Yield region)

→ The point C is known as upper yield point at which there will be sudden increase in strain without increase stress.

→ The point D is known as lower yield point beyond which the body will behave the property of plasticity.

From DE (strain hardening region)

→ In this region again the stress is directly propotional to the point. Here, permanent differmation of body will occur.

→ The point E is known as the ultimate point which indicate the maximum load for which the body can with stand.

From EF (Fracture / failure region)

→ This region is known as failure region which occur due to excid of load beyond the ultimate point.

→ Here the neck formation of body will occure. The body will rupture or fail at the point F; which is known as failure load or fracture load.

Elasticity

It is the property of a material, so that it will regain it's original shape & size after the removal of load.

Ductility

It is the property of a material by virtue of which it allow the formation of wire under the application of tensile force.

Elastic limit

It is the maximum difformation of a body beyond which the body will not regain its original shape & size after the removal of force.

plasticity

If a body will undergo permanent difformation under the application of external load. then that property of material is known as plasticity.

* Hook's Law

Within the elastic limit stress is directly propotional to strain.

$$\sigma \propto e$$

$$\Rightarrow \sigma = Ee$$

where,

E is called constant of propotionality or young's modulus of elasticity

Unit $E = \frac{\sigma}{e}$ $\boxed{N/m^2}$ or $\boxed{N/mm^2}$

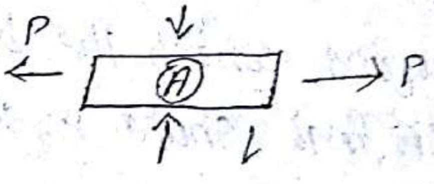
* Factor safety (F.S)

It is the ratio between the ultimate stress to the allowable stress.

$$F.S. = \frac{\text{Ultimate stress}}{\text{allowable stress}}$$

* Elongation of bar

$$E = \frac{\delta}{e}$$



$$= \frac{(P/A)}{(\delta L/L)}$$

$$\Rightarrow \frac{\delta L}{L} = \frac{P/A}{E} = \frac{P}{AE}$$

$$\Rightarrow \delta L = \frac{PL}{AE}$$

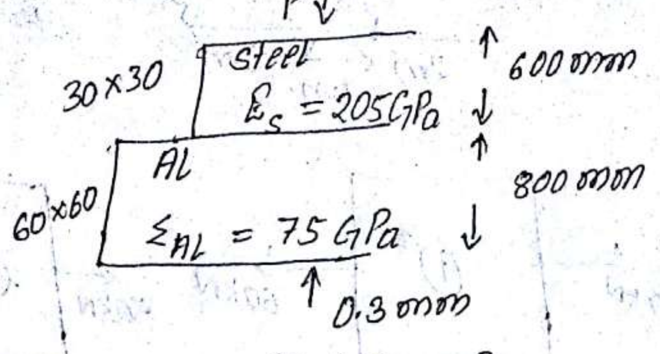
* principle of Superposition

The principle of superposition state that,

" If a body is acted upon a number of loads on various segment of a body, then the net effect of the body is the sum of the effect caused by each of the load acting independently on respective segment of the body."

problem based on principle of superposition

Ques no. (1)



If $\delta L = 0.3$ mm, find $P = ?$

Given data;

For steel, $L_S = 600$ mm,

$E_S = 205$ GPa,

$A_S = 30 \times 30 = 400\ mm^2$

For aluminium, $L_{AL} = 800$ mm,

$E_{AL} = 75$ GPa,

$A_{AL} = 3600\ mm^2$

$$\therefore \delta L = \frac{PL}{AE} = P\left[\frac{L_S}{A_S E_S} + \frac{L_{AL}}{A_{AL} E_{AL}}\right]$$

$$\Rightarrow 0.3 = P\left[\frac{600}{205 \times 900 \times 10^3} + \frac{800}{3600 \times 75 \times 10^3}\right]$$

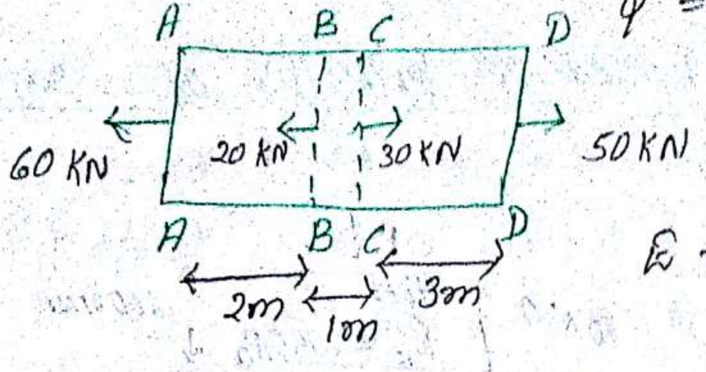
$$\Rightarrow P = \frac{\cancel{0.0032 + 0.0029}}{\cancel{0.3}} =$$

$= 48309$ N

$= 48.27$ KN

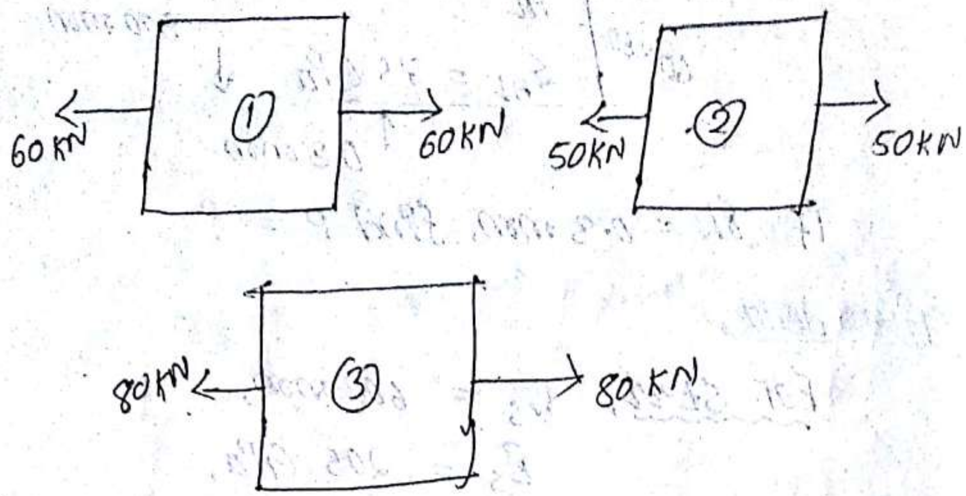
(2)

$\phi = 25\,mm$



$E = 190\,GPa$

Ans.



$$\delta L = \frac{PL}{AE}$$

Given data.

Here, ~~FOS 1~~

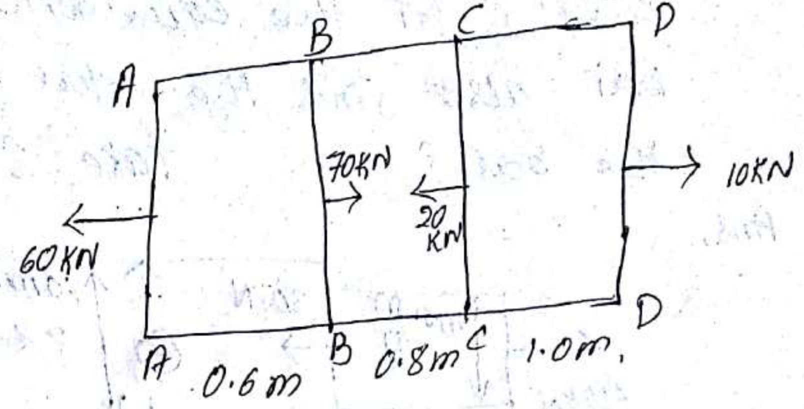
$$L_1 = 2m = 2000\,mm$$
$$L_2 = 1m = 1000\,mm$$
$$L_3 = 3m = 3000\,mm$$
$$A = \frac{\pi}{4}(25)^2 = 1962.5\,mm^2$$
$$E = 190\,GPa = 190\times10^9\,MPa$$
$$P_1 = 60\,KN = 60000\,N$$
$$P_2 = 50\,KN = 50000\,N$$
$$P_3 = 80\,KN = 80000\,N$$

$$\delta L = \frac{1}{AE}\left[P_1L_1 + P_2L_2 + P_3L_3\right]$$

$=$

(3) A brass bar having cross-section area of 900 mm^2 is subjected to axial forces as shown in figure in which AB = 0.6 m, BC = 0.8 m & CD = 1.0 m. Find the total elongation of the bar. Take $E = 1 \times 10^5$ N/mm^2 ?

Ans.



Given data,

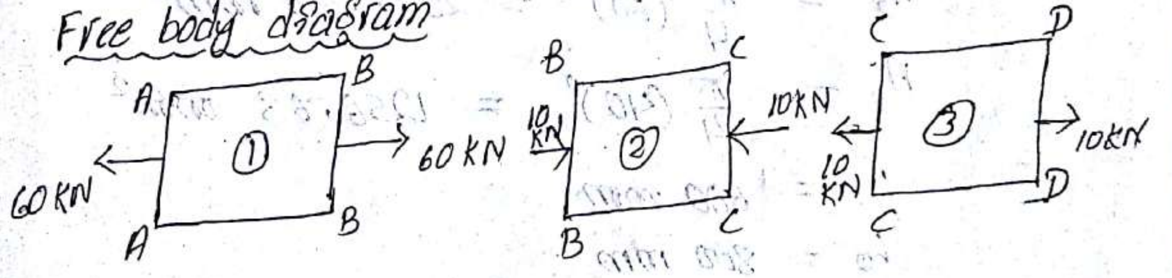
AB = 0.6 m = 600 mm

BC = 0.8 m = 800 mm

CD = 1.0 m = 1000 mm

$E = 1 \times 10^5$ N/mm^2

Free body diagram



Total elongation (δL)

$$= \frac{PL}{AE}$$

$$= \frac{1}{AE}[P_1L_1 - P_2L_2 + P_3L_3]$$

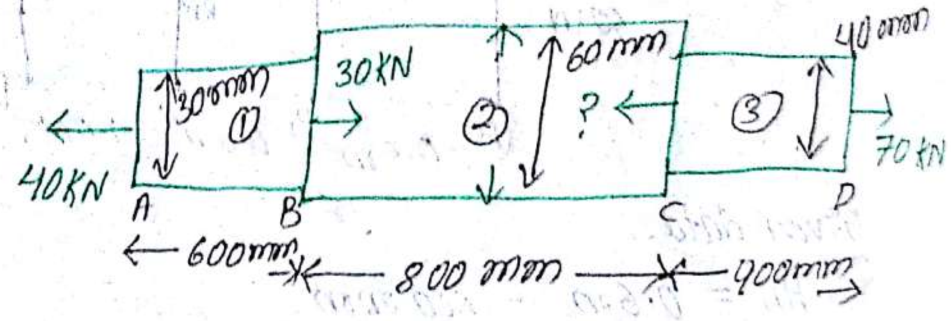
$$= \frac{1}{AE}[60 \times 600 - 10 \times 800 + 10 \times 1000]$$

$$= \frac{1}{AE} \times 38000$$

$$= \frac{1}{900 \times 1 \times 10^5} \times 38000 = 4.2 \times 10^{10} \text{ mm}$$

Q. A circular steel bar having 3 segment is subjected to various forces at different cross-section as shown in the fig. Determine the required force to be applied at section C for the equilibrium of the bar also find the total elongation of the bar? Take $E = 202\ GPa$

Ans.



Given data

$$A_1 = \frac{\pi}{4}(30)^2 = 706.85\ mm^2$$

$$A_2 = \frac{\pi}{4}(60)^2 = 2827.43\ mm^2$$

$$A_3 = \frac{\pi}{4}(40)^2 = 1256.63\ mm^2$$

$$L_1 = 600\ mm$$

$$L_2 = 800\ mm$$

$$L_3 = 900\ mm$$

$$E = 202\ GPa = 202 \times 10^3\ MPa$$

For equilibrium condition the net force along the axis is zero.

$$40 + P = 30 + 70$$

$$\Rightarrow P = 60\ KN$$

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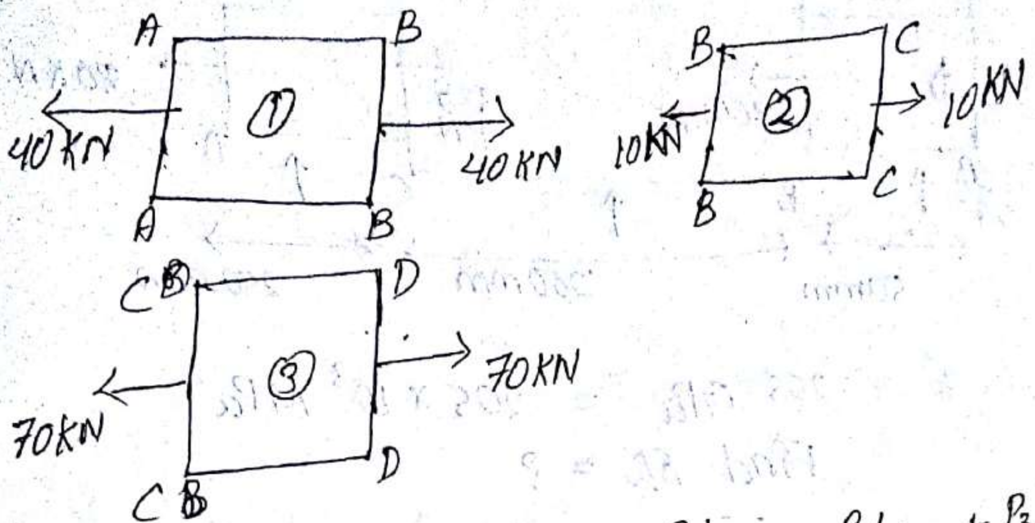
Total elongation

Free body diagram



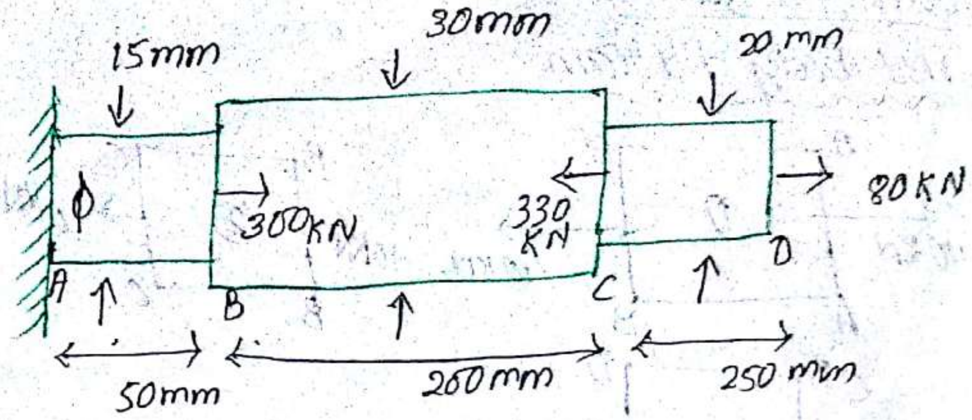
$$\delta L = \frac{PL}{AE} = \frac{1}{E}\left(\frac{P_1L_1}{A_1} + \frac{P_2L_2}{A_2} + \frac{P_3L_3}{A_3}\right)$$

$$= \frac{1}{E}(33.95 + 19.80 + 7.16)$$

$$= \frac{1}{202 \times 10^3}(60.91)$$

$$= \frac{60.91}{202000} = 0.000302$$

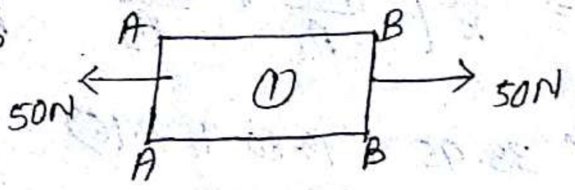
Q8

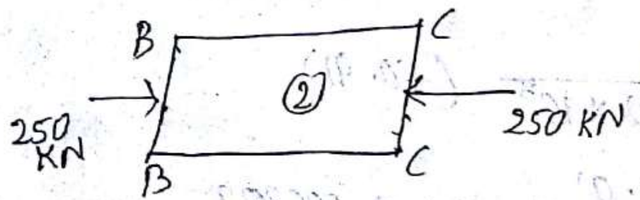


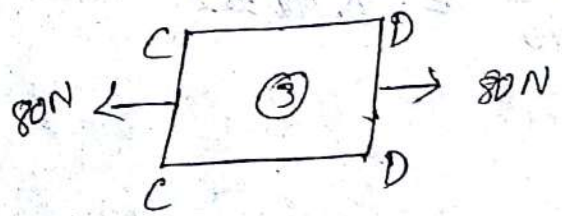
$$E = 205 \text{ GPa} = 205 \times 10^3 \text{ MPa}$$

Find $\delta L = ?$

Ans:







Given data;

$L_1 = 50 \text{ mm}$

$L_2 = 200 \text{ mm}$

$L_3 = 250 \text{ mm}$

$P_1 = 50 \text{ N}$

$P_2 = 250 \text{ N}$

$P_3 = 80 \text{ N}$

$A_1 = \frac{\pi}{4}(15)^2 = 706.5 \text{ mm}^2$

$A_2 = \frac{\pi}{4}(30)^2 = 2826 \text{ mm}^2$

$A_3 = \frac{\pi}{4}(20)^2 = 1256 \text{ mm}^2$

$$\delta L = \frac{PL}{AE}$$

$$= \frac{1}{E}\left(\frac{P_1 L_1}{A_1} + \frac{P_2 L_2}{A_2} + \frac{P_3 L_3}{A_3}\right)$$

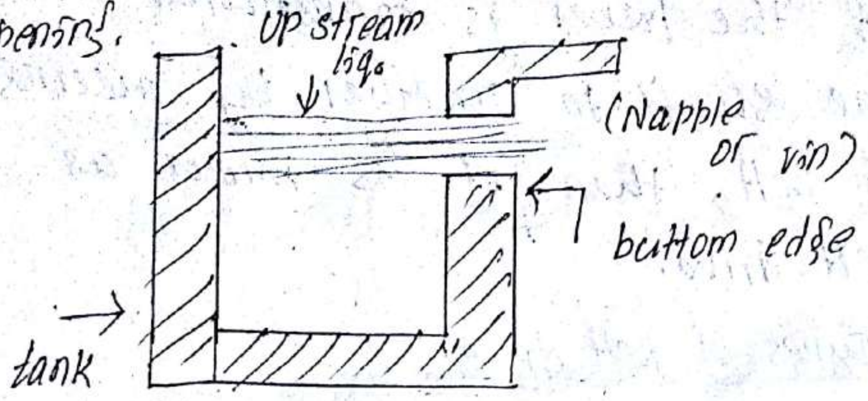
$$= \frac{1}{205 \times 10^3}\left(\frac{50 \times 50}{706.5} + \frac{250 \times 200}{2826} + \frac{80 \times 250}{1256}\right)$$

$$= \frac{1}{205 \times 10^3}\left(3.53 + 17.69 + 15.92\right)$$

$$= 0.00018 \text{ mm.}$$

Notch

It is defined as an opening in one side of a tank on a reserver, with like a large orifice, with the up-stream liq. level below the top edge of the opening.



Types

(1) Rectangular notch

$$Q = \frac{2}{3} cd \times b\sqrt{2g}\ (H)^{3/2}$$

(2) Trangular notch or V-shape notch

$$Q = \frac{8}{15} cd \sqrt{2g}\ \tan\frac{\theta}{2} \times H^{5/2}$$

(3) Trapezoidal Notch

$$Q = \frac{2}{3} cd_1 \times S\sqrt{2g}\ (H)^{3/2} + \frac{8}{15} cd_2\sqrt{2g}\ \tan\frac{\theta}{2} \times H^{5/2}$$

(4) stepped Notch

$$Q = Q_1 + Q_2$$

$$= \frac{2}{3} cd\ S_1\sqrt{2g}\ H_1^{3/2} + \frac{2}{3} cd\ S_2\sqrt{2g}\ (H_2^{3/2} - H_1^{3/2})$$

Belt, Rope & chain drive

Belt drive

If the power is transmited from one shaft to another by means of belt, then it is known as belt drive.

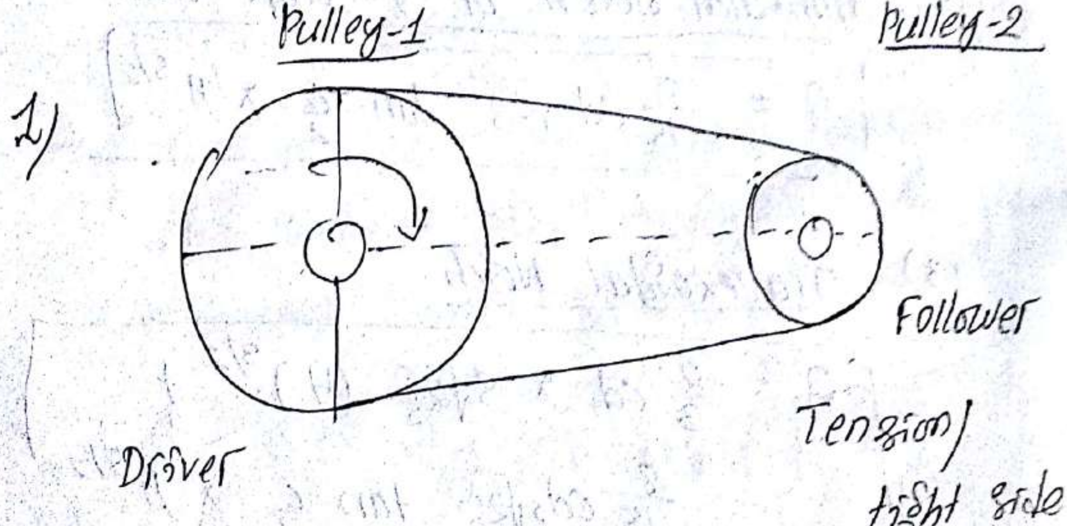
Types of belt drive

2 - types -

(1) Open belt drive

(2) ~~close~~ cross belt drive

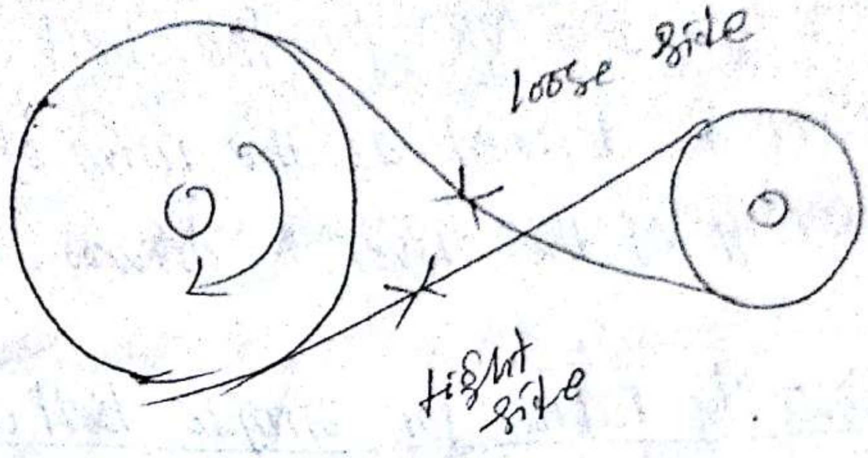
1)



Tension at the lower side is maximum & in upper side is minimum.

Driver & driven are in same dir^n.

2)



Driver & driven are in opposite dirn.

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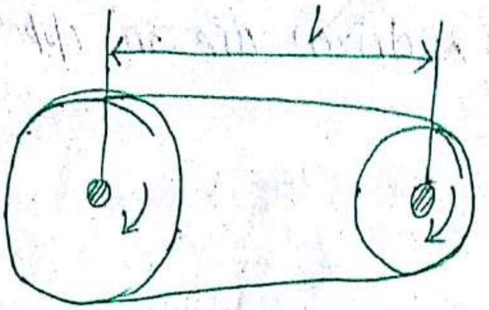
Velocity ratio

Velocity ratio (VR) for the belt driver is defined as the ratio of the velocity of the driver & driven.

Velocity ratio for simple belt drive



Pulley-1 (Driver)

Pulley-2 (Driven/follower)

In simple belt drive there is only one driver & one driven.

Let,

d_1 = diameter of the pulley one

N_1 = speed of the pulley one in rpm

V_1 = velocity of the pulley one

Let,

d_2 = diameter of the pulley two

N_2 = speed of the pulley two in rpm

V_2 = velocity of the pulley two

rpm → revolution per minute

length of the belt that passes over the driver in one minute $= \pi d_1 N_1$

length of the belt that passes over the driven in one minute $= \pi d_2 N_2$

Length of the belt that pass over the driver in one minute is equal to length of the belt pass over the driven in one minute.

so,

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

$$\Rightarrow \boxed{\frac{N_1}{N_2} = \frac{d_2}{d_1}}$$

The term $\frac{N_1}{N_2}$ is known as the velocity ratio.

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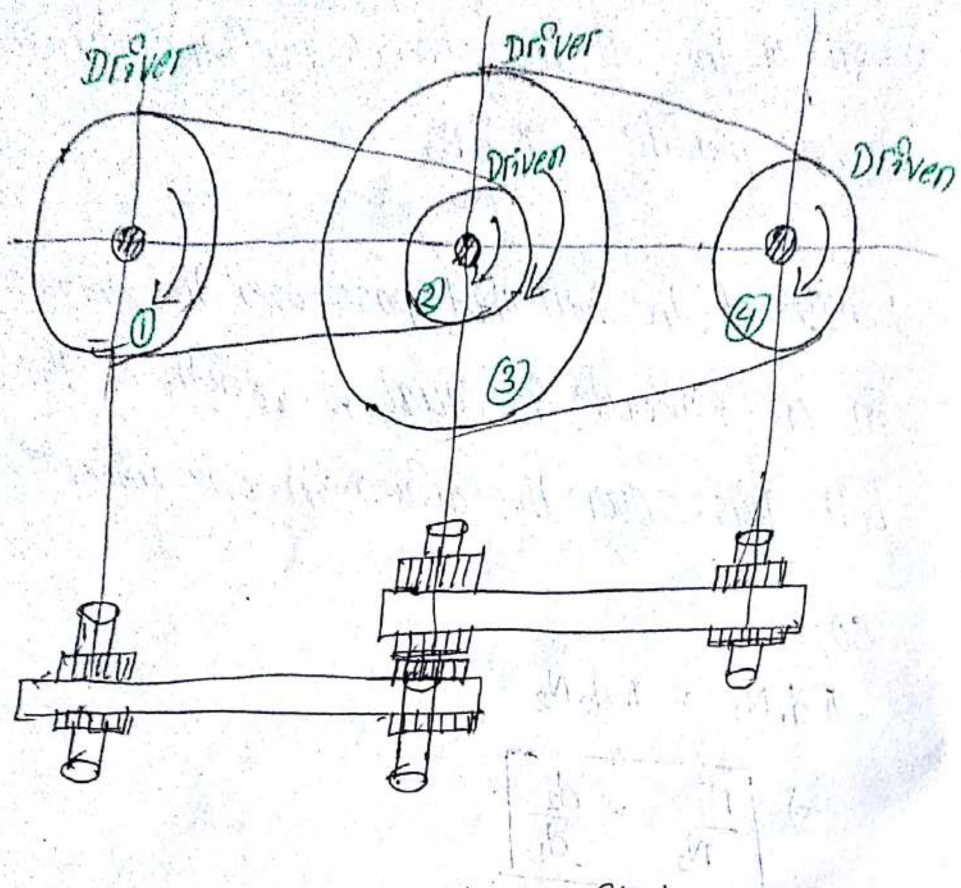
Velocity ratio for compound belt drive



If the power is transmitted from one Shaft to another through a number of pullies then such arrangement is known as compound belt drive.

Let,

D_1 = Diameter of pulley one

N_1 = speed of the pulley one in rpm

& $D_2, D_3, D_4, N_2, N_3, N_4$ = corresponding value of pulley 2, 3, 4

Now, VR of pulley one & two,

$$\boxed{\frac{N_1}{N_2} = \frac{D_2}{D_1}} \quad \text{——— (1)}$$

VR of pulley three & four,

$$\boxed{\frac{N_3}{N_4} = \frac{D_4}{D_3}} \quad \text{——— (2)}$$

Multiplying equ^n (1) & (2),

$$\frac{N_1}{N_2} \times \frac{N_3}{N_4} = \frac{D_2}{D_1} \times \frac{D_4}{D_3}$$

As pulley (2) & (3) are mounted on the same shaft,

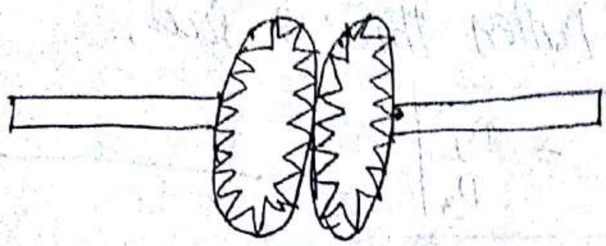
so, $N_2 = N_3$

$$\Rightarrow \boxed{\frac{N_1}{N_4} = \frac{D_2 \times D_4}{D_1 \times D_3}}$$

$$= \frac{\text{product of diameter of even number of pulley}}{\text{product of diameter of odd number of pulley}}$$

GEAR DRIVE

If the power is transmited from one shaft to another through the gear is known as gear drive.



Velocity ratio of gear drive

It is the ratio betn velocity of the driver gear to the driven gear.

Pitch

It is the ratio between circumference area of the gear & total number of teeth.

pitch is also defined as the minimum distance between two consucutive teeth.

* Two gears will be meshed with each other if they are having same pitch value.

Imp

Ques

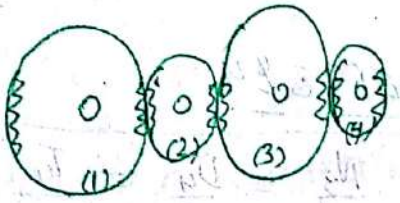
Explain simple gear train ?

Ans :

When a number of gears are arranged to transmit the power from one shaft to another, then this is known as the ~~simple~~ gear train.

Simple gear train

If there is only one gear on each shaft, then the arrangement is known as simple gear train.



Let,

D_1 = pitch circle diameter of gear one

N_1 = speed of the gear one in rpm

T_1 = Number of teeth on gear one

& $D_2, D_3, D_4, N_2, N_3, N_4, T_2, T_3$ & T_4 equal to corresponding value for gear 2, 3 & 4.

As we know two gears will be meshed if they are having same pitch.

For Gear 1 & 2

Pitch of the Gear (1) = Pitch of the Gear (2)

$$\Rightarrow \frac{\pi D_1}{T_1} = \frac{\pi D_2}{T_2}$$

$$\Rightarrow \frac{D_1}{T_1} = \frac{D_2}{T_2} \Rightarrow \boxed{\frac{D_2}{D_1} = \frac{T_2}{T_1}}$$

Now, velocity ratio :-

$$\boxed{(VR) = \frac{N_1}{N_2} = \frac{D_2}{D_1} = \frac{T_2}{T_1}} \quad \text{— (1)}$$

VR for Gear 2 & 3

$$\boxed{VR = \frac{N_2}{N_3} = \frac{D_3}{D_2} = \frac{T_3}{T_2}} \quad \text{— (2)}$$

VR for Gear 3 & 4

$$\boxed{VR = \frac{N_3}{N_4} = \frac{D_4}{D_3} = \frac{T_4}{T_3}} \quad \text{— (3)}$$

Multiplying equ^n (1), (2) & (3)

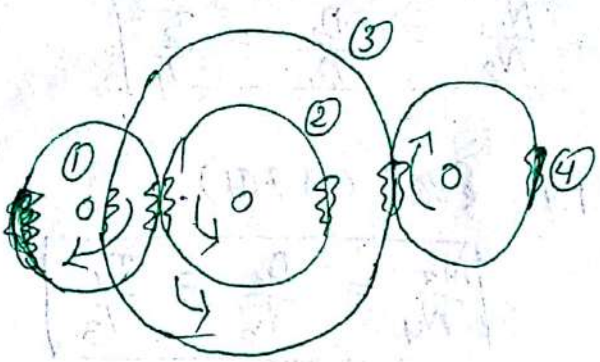
$$\frac{N_1}{\cancel{N_2}} \times \frac{\cancel{N_2}}{\cancel{N_3}} \times \frac{\cancel{N_3}}{N_4} = \frac{\cancel{D_2}}{D_1} \times \frac{\cancel{D_3}}{\cancel{D_2}} \times \frac{D_4}{\cancel{D_3}}$$

$$= \frac{\cancel{T_2}}{T_1} \times \frac{\cancel{T_3}}{\cancel{T_2}} \times \frac{T_4}{\cancel{T_3}}$$

$$\Rightarrow \boxed{\frac{N_1}{N_4} = \frac{D_4}{D_1} = \frac{T_4}{T_1}}$$

Explain compound gear train

If a number of gears are arranged in such a way that one shaft may have both driver & driven, then this type of arrangement is known as compound gear train.



Let,

D_1 = pitch circle diameter of gear one

N_1 = Speed of the gear one in rpm

T_1 = Number of teeth on gear one

& $D_2, D_3, D_4, N_2, N_3, N_4, T_2, T_3, T_4$ equal to corresponding value for gear 2, 3 & 4.

As we know two gear will be meshed if they are having same pitch.

For gear 1 & 2

pitch of gear (1) = pitch of gear (2)

$$\Rightarrow \frac{\pi D_1}{T_1} = \frac{\pi D_2}{T_2}$$

$$\Rightarrow \frac{D_1}{T_1} = \frac{D_2}{T_2} \Rightarrow \boxed{\frac{D_2}{D_1} = \frac{T_2}{T_1}} \quad \text{---(1)}.$$

Now, VR,

$$\boxed{\frac{N_1}{N_2} = \frac{D_2}{D_1} = \frac{T_2}{T_1}} \quad \text{---(1)}$$

For gear (3) & (4),

$$\boxed{\frac{N_3}{N_4} = \frac{D_4}{D_3} = \frac{T_4}{T_3}} \quad \text{---(2)}$$

Now, multiply (1) & (2),

$$\frac{N_1}{\cancel{N_2}} \times \frac{\cancel{N_3}}{N_4} = \frac{D_2 \times D_4}{D_1 \times D_3} = \frac{T_2 \times T_4}{T_1 \times T_3}$$

$$\Rightarrow \boxed{\frac{N_1}{N_4} = \frac{D_2 \times D_4}{D_1 \times D_3} = \frac{T_2 \times T_4}{T_1 \times T_3}}$$

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Fly wheel

→ It is used to control the variation in speed during each cycle of an operation.

→ It will store the excess energy when supply of energy is more & release the energy when supply is less.

→ It will act as a reservoir of energy.

GOVERNER

→ The function of a governer is to regulate the mean speed of an engine under the variation of load.

→ when load on the engine increases its speed decreases, so supply of fuel will be more to maintain the mean speed of an engine.

→ when the load on the engine decreases its speed increases, so fuel supply should be reduce to maintain the mean speed of an engine.

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Type of Governor

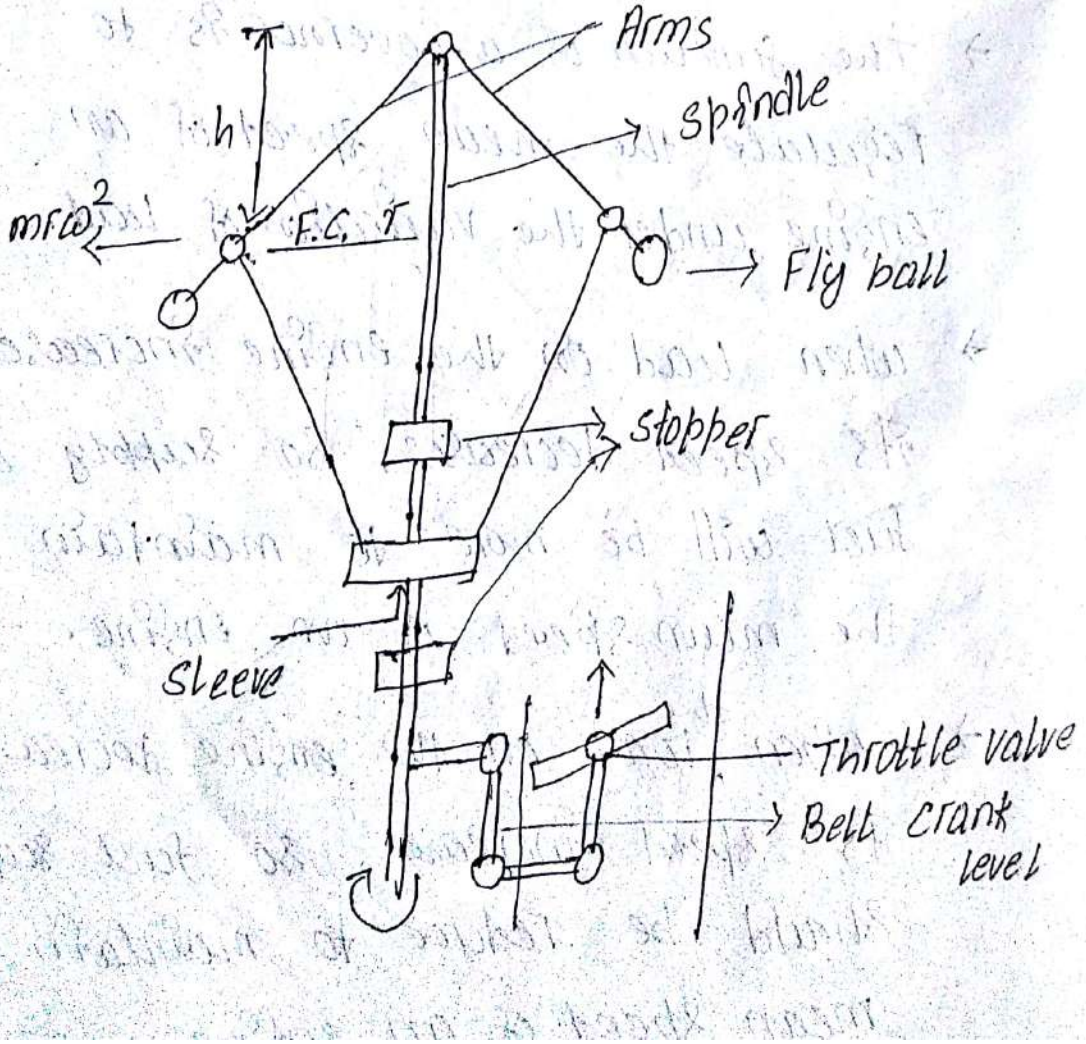
(1) centrifugal governor
(2) Inertia governor

Centrifugal governor

centrifugal governor are following types.

① watt governor
② porter governor
③ proell governor

Q. Explain the working principle of watt governer ?



→ It is the simplest type of centrifugal governer.

→ It consist of two fly ball attached to the sleeve of negligible mass.

→ The upper ends of the arm are pivorted to the spindle.

→ The engine drives the spindle. The lower arms are connected to the sleeve.

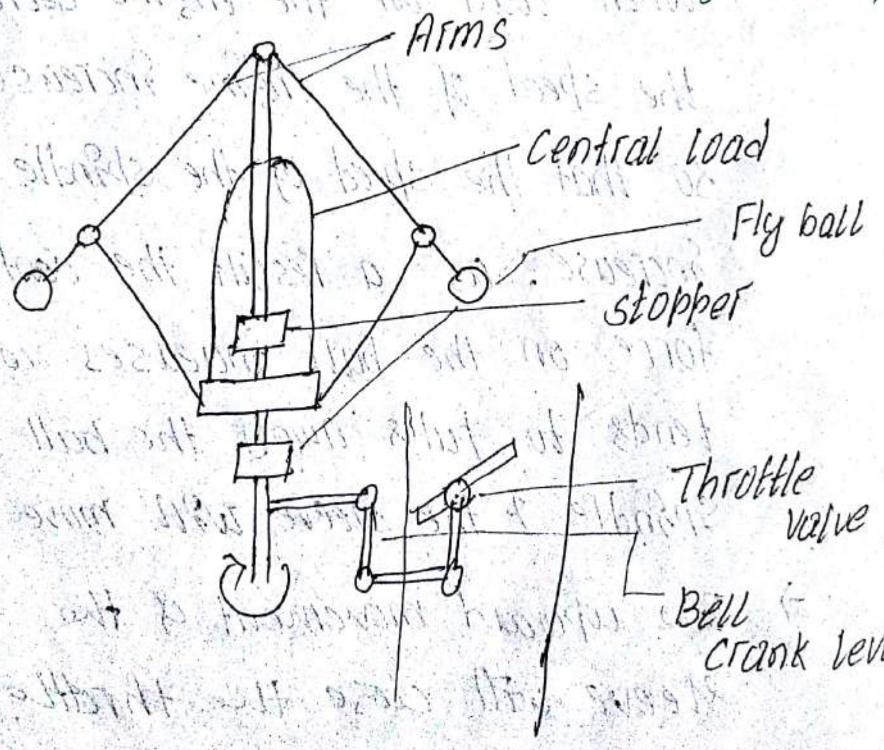
→ The sleeve is the keyed to the spindle shaft so that sleeve will rotate with the rotation of spindle.

→ When load on the engine decreases the speed of the engine increases, so that the speed of the spindle is also increase; as a result the centrifugal force on the ball increases which tends to pulls away the ball from spindle & the sleeve will move upward.

→ The upward movement of the sleeve will close the throttle valve as a result the fuel supply will be reduce.

→ When the load on the engine increases, the speed of the engine decreases, so that the speed of the spindle decreases as a result the centrifugal force on the ball decreases which tends to pulls towords the spindle & the sleeve will move downword; which cause the throttle valve open to increase the fuel supply.

Explain the working principle of portor governor?



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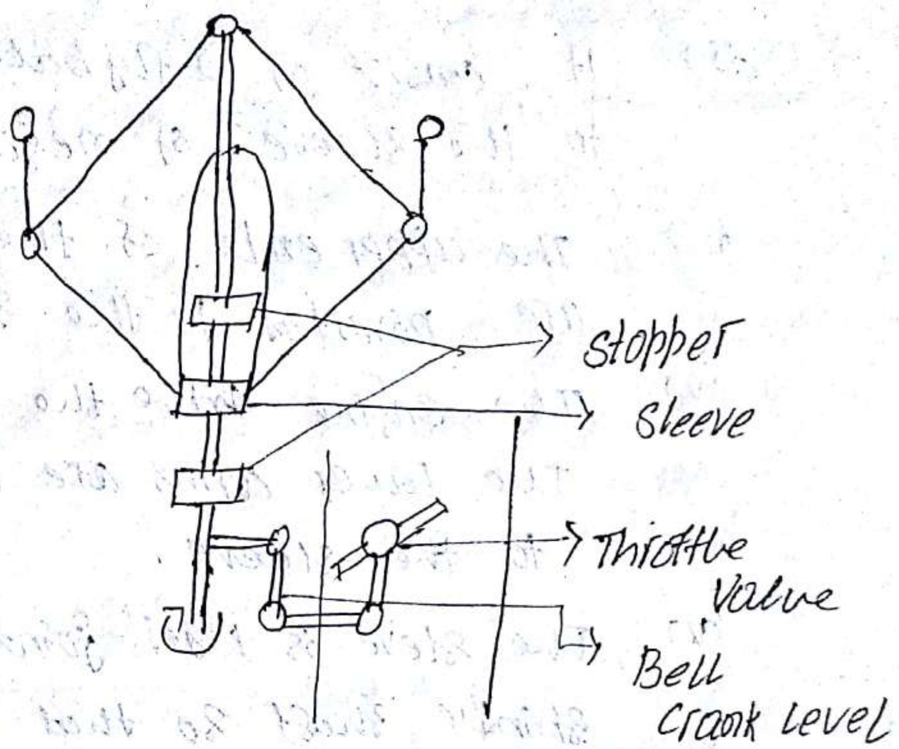
It is simillar to the watt governer except a heavy central load is attached to the sleeve.

W.P: (same copy)



It is simillar to the portor governor except the fly balls are attached to the extension link upward.

W.P (same portor governor)

... be one fixed

Porter governer

i) It is similar to the watt governer except a heavy central load is attached to the sleeve.

ii) It consist of 2 fly ball attached to the sleeve of negligible mass.

iii) The upper ends of the arm are pivoted to the spindle.

iv) The engine drive the spindle, The lower arms are connected to the sleeve.

v) The sleve is keyed joint to the spindle shaft so that sleave will rotate with the rotation of spindle.

vi) when load on engine decreases, the speed of the engine increases so that the speed of the spindle also increases, as a result the centrifugal force on the ball increases, which tends to pull away the ball from the spindle & the sleave will move upward.

(vii) The upward movement of the sleeve close the throttle valve as a result the fuel supply will reduced.

(viii) When the load on the engine increases, speed will decreases. so that centrifugal force of the ball reduced, which pulls towards the spindle and the sleeve will move downward which close the throttle valve open to increase the fuel supply.

Proell governer

→ It is the similar to the porter governor except the flyball are attached to the extension link upward. In this type of governer the flyball will attached with the extension link upwardly.

→ Here the same process will proceed. The sleeve is keyed joint to the spindle shaft so that the sleeve will rotate with the rotation of the spindle.

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→ When the load on the engine decreases, the speed of the engine increases; so that the speed of the spindle will also increases. As a result the centrifugal force on the ball increases, which tends to pull away the ball from the spindle & the sleeve will move upward.

→ The upward movement of the sleeve close the throttle valve. As a result the fuel supply will reduced.

→ When the load on the engine increases, speed will decrease; so that centrifugal force of the ball reduced, which pulls towards the spindle & the sleeve will move downward which close the throttle valve open to increase the fuel supply.

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Air standard cycle assumption

1. All the process are reversible process.
2. Air is assume to behave as ideal gas.
3. The mass of air remain constant.
4. There will be no phase change in working fluid.
5. Heat is added & rejected with external source.

Describe otto cycle with PV & TS diagram

Otto cycle is also known as petrol cycle or spark ignition cycle.

It consist of 4 process -

(i) Reversible adiabatic compression
(ii) Reversible adiabatic expansion
(iii) constant volume heat addition
(iv) constant volume heat rejection.

process 1-2 (Reversible adiabatic compression)

→ Here, the air is compressed reversibly and adiabatically.

→ Pressure increases from P_1 to P_2 and volume decreases from V_1 to V_2.

→ Net heat transfer will be zero; so entropy will be remain constant.

Process 2-3 (constant volume heat addition)

→ Here heat is added to the air at constant Volume.

→ Volume will be constant & pressure increases from P_2 to P_3.

→ Heat supply,

$$\boxed{Q_{sup} = mC_v (T_3 - T_2)}$$

Q_{sup} = Heat supply

m = mass of air

C_v = specific gravity at constant vol.

Process 3-4 (Reversible adiabatic expansion)

→ Here the air expanded reversibly & adiabatically.

→ pressure reduces from P_3 to P_4, & Volume increases from V_1 to V_2.

→ Net heat transfere will be zero, so entropy will be remain constant.

Process (4-1) (Constant volume heat rejection)

→ Here, heat will rejected at constant volume.

→ pressure reduces P_4 to P_1 & volume constant.

→ Heat rejection,

$$\boxed{Q_{exist} = mC_v(T_4 - T_1)}$$

* Effeciency (η) = $\frac{\text{Heat supply - heat rejection}}{\text{Heat supply}}$

$$= \frac{mC_v(T_3 - T_2) - mC_v(T_4 - T_1)}{mC_v(T_3 - T_2)}$$

$$= \frac{(T_3 - T_2) - (T_4 - T_1)}{(T_3 - T_2)}$$

$$\Rightarrow \boxed{\eta = 1 - \left(\frac{T_4 - T_1}{T_3 - T_2}\right)} \quad \text{—— (1)}$$

$$\Rightarrow \boxed{\eta = 1 - \left(\frac{V_2}{V_1}\right)^{\gamma - 1}}$$

Process (1-2) = $\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma - 1}$

Process (3-4) = $\frac{T_3}{T_4} = \left(\frac{V_4}{V_3}\right)^{\gamma - 1} = \left(\frac{V_1}{V_2}\right)^{\gamma - 1}$

$$\Rightarrow \frac{T_2}{T_1} = \frac{T_3}{T_4} \quad \Rightarrow \frac{T_3}{T_2} = \frac{T_4}{T_1}$$

$$\Rightarrow \frac{T_3}{T_2} - 1 = \frac{T_4}{T_1} - 1$$

$$\Rightarrow \frac{T_3 - T_2}{T_2} = \frac{T_4 - T_1}{T_1}$$

$$\Rightarrow \boxed{\frac{T_1}{T_2} = \frac{T_4 - T_1}{T_3 - T_2} = \left(\frac{V_2}{V_1}\right)^{\gamma - 1}} \quad \text{--- (2)}$$

$$\Rightarrow \frac{T_1}{T_2} = \left(\frac{V_2}{V_1}\right)^{\gamma - 1}$$

Now putting this value in eqn (1),

we have

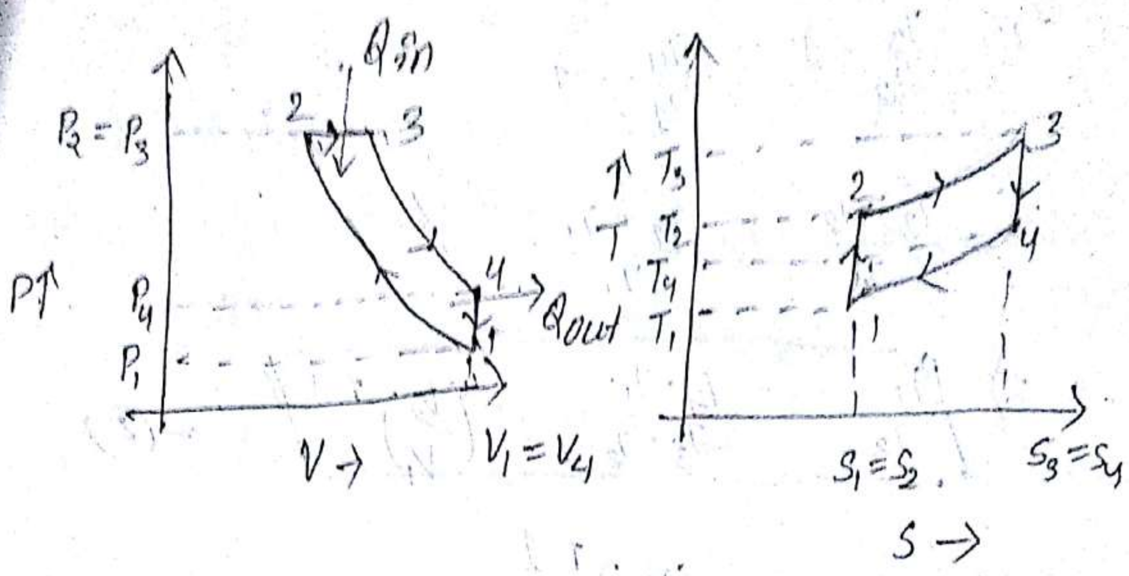
$$\eta = 1 - \left(\frac{T_4 - T_1}{T_3 - T_2}\right)$$

$$= 1 - \left(\frac{V_2}{V_1}\right)^{\gamma - 1}$$

$$= 1 - \frac{1}{\left(\frac{V_1}{V_2}\right)^{\gamma - 1}}$$

$$= \boxed{1 - \frac{1}{(r)^{\gamma - 1}}}$$

Diesel cycle (C.I. engine)



→ Diesel cycle is also known as compression ignition cycle.

→ This cycle consists of 4 process

① Reversible adiabatic compression

② constant pressure of heat addition (isobaric)

③ Reversible adiabatic expansion

④ constant volo of heat rejection (Isochoric)

Process (1-2) (Reversible adiabatic compression)

→ The air is compressed reversibly & adiabatically.

→ pressure & temp. increases from 1 to 2.

→ No heat transfer taking place; so entropy will remain constant.

Process (2-3) (Isobaric heat addition)

→ Here the heat will be added at constant pressure.

→ Here temperature & volume increases.

→ Heat supplied;

$$\boxed{Q_{in} = mC_p(T_3 - T_2)}$$

Process (3-4) (Reversible adiabatic expansion)

→ The air is expand reversible & adiabatically.

→ pressure & temp. decreases from 3 to 4.

→ No heat transfer taking place : so entropy will remain constant.

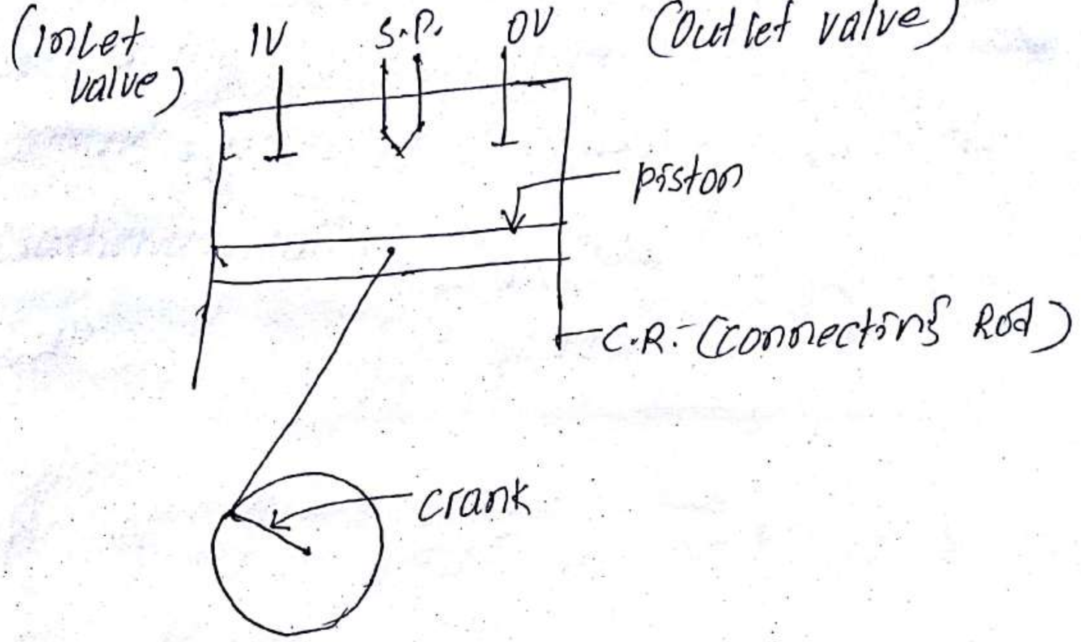
Process (4-1) (Constant vol. of heat rejection)

→ Here, heat is rejected at constant volume.

→ Both temp & pressure decreases.

→ Heat rejection; $\boxed{Q_{out} = mC_v(T_4 - T_1)}$

Working principle of 4-stroke petrol engine



4- stroke petrol engine consists of following stroke

(1) suction stroke

(2) compression stroke

(3) Expansion / working / power stroke

(4) Exhaust stroke

IHP → Indicated Horse power

It is the power available / produce inside the engine cylinder due to burning of fuel.

Mathematically,

$$IHP = \frac{P \cdot L \cdot A \cdot N}{60} \text{ watt}$$

where,

P = Pressure acting on the piston in N/m^2

l = length of stroke in m

A = Area of piston in m^2

N = rpm (revolution per minute)

BHP → Break Horse power

→ The power available at the engine crank shaft is known as BHP.

→ It is the useful power.

→ Mathematically,

$$BHP = \frac{\omega T}{60} \text{ watt} = \frac{2\pi \dot{N} T}{60} \text{ watt}$$

where,

ω (omega) = angular speed in radian per sec.

T = Torque in Nm

N = rpm

η (Eta) mech (Mechanical efficiency)

→ It is the ratio between BHP & IHP.

→ $\eta \text{ mech} = \frac{BHP}{IHP} \times 100$

Fluid mechanics

Define fluid:

Fluid is defined as a substance which deforms (change in shape & size) continuously when subjected to tangential or shear stress.

It is the combination of both liq. & gas phase.

Properties of fluid:

① Density (ρ) (row)

→ It is defined as the mass of fluid per unit volume.

→ It is represented by 'ρ'.

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

→ Unit of ρ = kg/m^3, gm/cm^3 etc.

② Specific weight / weight density (ω) (omega)

→ It is defined as the weight of fluid per unit volume.

→ It is represented by 'ω'.

→ Mathematically, $\omega = \frac{W}{V} = \frac{mg}{V} = \rho g$

→ Unit of ω = N/m^3 etc.

③ Specific volume (v)

→ It is defined as the volume of fluid per unit mass.

→ It is reciprocal of density.

→ mathematically,

$$v = \frac{1}{\rho} = \frac{V}{M}$$

④ Specific gravity (S)

(For liq)

→ It is the ratio betn density of any liq. to the density of water at 1 atm pressure & 4°c temp.

→ mathematically,

$$S = \frac{\rho \text{ liq.}}{\rho \text{ water}}$$

(For gas)

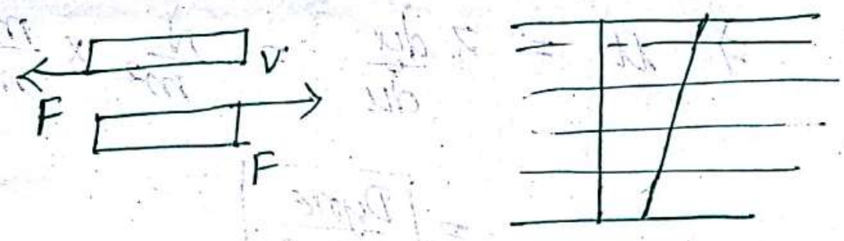
→ It is the ratio betn density of any gas to the density of air or hydrogen at normal condition.

mathematically,

$$S = \frac{\rho_{gas}}{\rho_{air}}$$

$$\boxed{\rho_{air} = 1.12\ kg/m^3}$$

5) Viscosity



It is the property of fluid by virtue of which it will provide a resistance to the sliding of one layer of liq. over another layer.

(For liq)

Viscosity increases if temp decreases.

(For gas)

Viscosity increases if temp increases.

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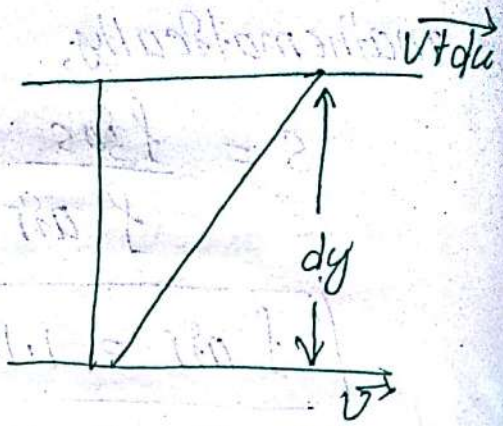
Unit of Viscosity



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

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

where, μ = coefficient of viscosity or, dynamic viscosity

$$\Rightarrow \mu = \tau \frac{dy}{du} = \frac{N}{m^2} \times \frac{m}{m/s} = \boxed{\frac{NS}{m^2}}$$ in S.I.

$$= \boxed{\frac{Dyne}{Cm^2}}$$ in C.G.S.

Kinetic Viscosity

$$\nu = \frac{\mu}{\rho} = \frac{\text{dynamic viscosity}}{\text{density}}$$

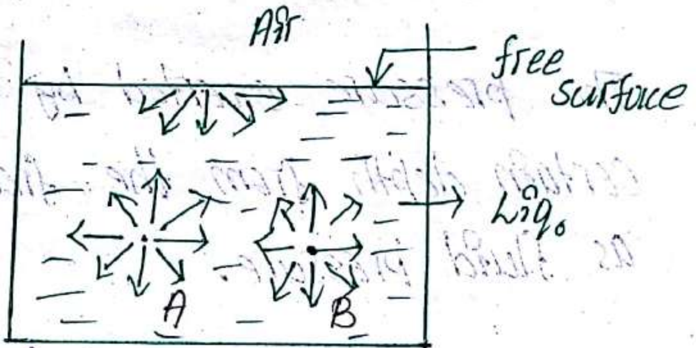
$$= \frac{\frac{NS}{m^2}}{\frac{M}{m^3}} = \frac{NS}{m^2} \times \frac{m^3}{M} = \frac{MLT^{-2} \times T}{L^2} \times \frac{L^3}{M}$$

$$= L^2T^{-1} = \boxed{\frac{m^2}{s}}$$ in S.I.

τ = tau
μ = mew
ν = new
σ = sigma

Surface tension (σ_s)

It is the property of liq. by virtue of which it behaves like a stretch elastic membrane under tension at the free surface.



It is denoted by σ_s.

mathematically, $\sigma_s = \frac{F}{L}$

Unit: N/m

Compressible & In-compressible

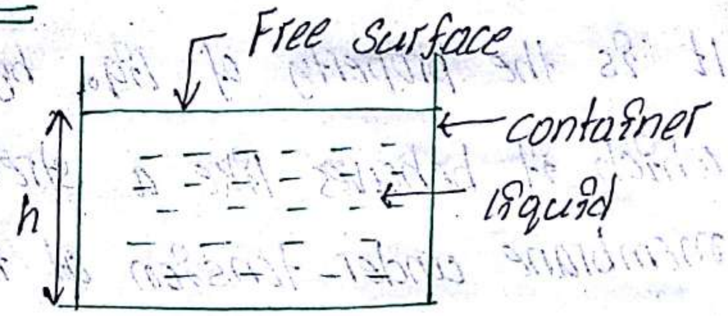
Compressible: density vary

In-compressible: density constant

Capillary effect

The rise or fall of liquid inside a small diameter tube when inserted into liq.

Fluid pressure



The pressure exerted by the fluid at a certain depth from the free surface is known as fluid pressure.

It always act normal to the surface.

It depends on density of liq. & the height of surface from the free surface of liq..

$$\boxed{P = \rho g h}$$

where, ρ = density in kg/m^3

g = gravitational acceleration in m/sec^2

h = height in m.

Pascal law

The law states that, "for a static fluid the pressure at any point remains constant in a horizontal direction."

Pressure Head

It is the height of liq. column to describe the fluid pressure.

Mathematically,

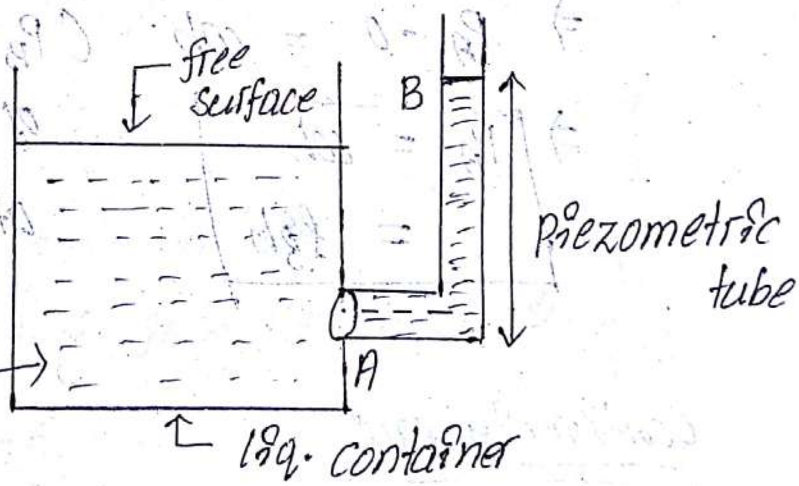
$p = \rho g h$

$\Rightarrow h = \frac{p}{\rho g} = \frac{p}{\omega}$

Unit : m

Imp. Q.

State & explain working principle of pressure measuring device piezometer tube ?



(FIG. OF: Piezometer tube)

(i) It is an open glass tube which is used to measure the moderate liq. pressure.

(ii) Its one end is connected to a point at which pressure will be calculated & other end will open to atmosphere.

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(iii) It will measure only gauge pressure.
(+ve)
It is not suitable for measuring -ve pressure i.e. vaccum pressure.

(iv) The rise of liq. in a piezometer tube will indicate the pressure head at the point in a pipe or any vessel at which it is connected.

$\Delta P = \omega h$

$\Rightarrow P_A - P_B = \omega h$

$\Rightarrow P_A - 0 = \omega h$ ($P_B = 0$, as pressure of fluid is zero at free surface)

$$\Rightarrow \boxed{P_A = \omega h = \rho g h}$$

Continuity equ^n^

$\rightarrow A \propto \frac{1}{V}$

$\Rightarrow \boxed{AV = C}$

Here, conservation of mass occurs.

$\Rightarrow$ Mass flow rate $= \rho AV$

∴ For in-compressible fluid

$$\boxed{\rho_1 A_1 V_1 = \rho_2 A_2 V_2}$$ Equ^n of continuity

$$\Rightarrow \boxed{A_1 V_1 = A_2 V_2}$$ (for in-compressible fluid).

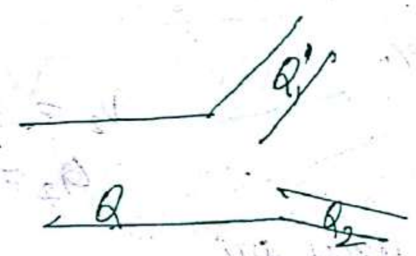
<u>Note</u>

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

$\dot{V}$ = Volume per sec

$$\dot{m} = \text{mass per sec} = \frac{\rho V}{t} = \frac{\rho A L}{t} = \boxed{\rho A V}$$

mass flow rate



$\dot{Q}$ = dis-charge per sec
= Vol. of fluid flowing per sec.

$$Q = Q_1 + Q_2$$

$$\therefore \dot{Q} = \frac{Vol}{sec}$$

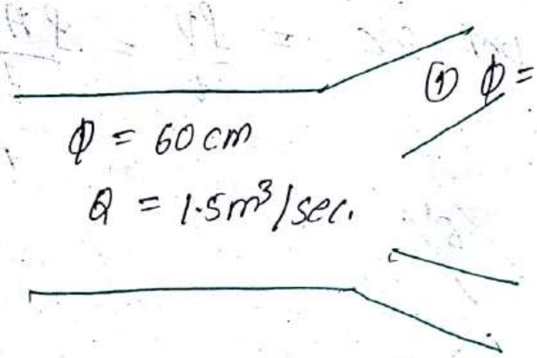
$$= \frac{A \times L}{T} = A \times V$$

$$\boxed{\therefore AV = A_1 V_1 + A_2 V_2}$$

Q. A pipe line 60 cm in diameter is divided into 2 branches 40 cm & 30 cm in diameter. If the rate of flow in the main pipe is $\boxed{1.5\ m^3/sec}$ & the mean velocity of the flow in the 30 cm pipe is 7.5 m/s. Determine the rate of flow in the 40 cm pipe?

dis-charge

Ans.



$$A = \frac{\pi}{4}(.6)^2 = 1.1304\ m^2$$

$$A_1 = \frac{\pi}{4}(.4)^2 = 0.5024\ m^2$$

$$A_2 = \frac{\pi}{4}(.3)^2 = .2826\ m^2$$

By principle of continuity eqn;

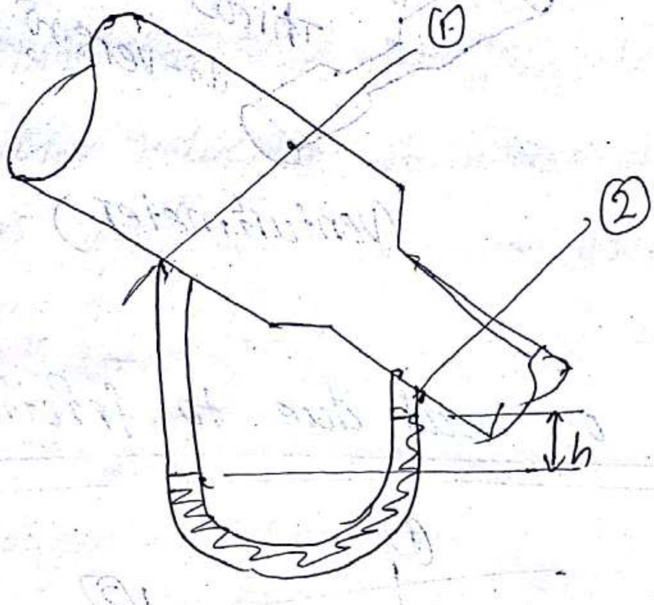
$$\boxed{Q = Q_1 + Q_2}$$

$$\Rightarrow A \times V = A_1 V_1 + A_2 V_2$$

$$\Rightarrow A_1 V_1 = A \times V - A_2 V_2$$

$$= 1.5 - (0.2826) \times (7.5)$$

$$= -0.6195 .$$



Here,

$P.E = P \times V = \frac{N}{m^2} \times m^3 = \boxed{Nm}$

$K.E = \boxed{\frac{1}{2} m v^2}$

$P.E = mgh$

$\therefore PV + \frac{1}{2} mv^2 + mgh = C$

head → per unit weight

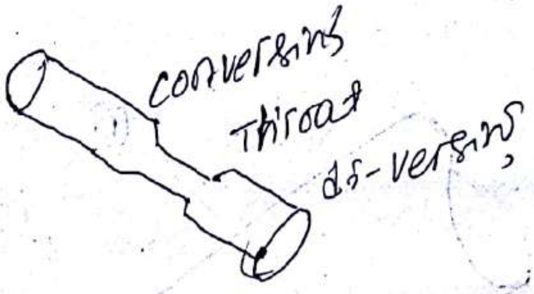
$\Rightarrow \frac{PV}{\omega} + \frac{1}{2}\frac{mv^2}{\omega} + \frac{mgh}{\omega} = C$

$\Rightarrow \frac{P}{(\frac{\omega}{V})} + \frac{1}{2}\frac{mv^2}{mg} + \frac{mgh}{mg} = C$

$\Rightarrow \boxed{\frac{P}{\rho g} + \frac{V^2}{2g} + h = C}$ $\boxed{\frac{Wet}{V} = \rho}$

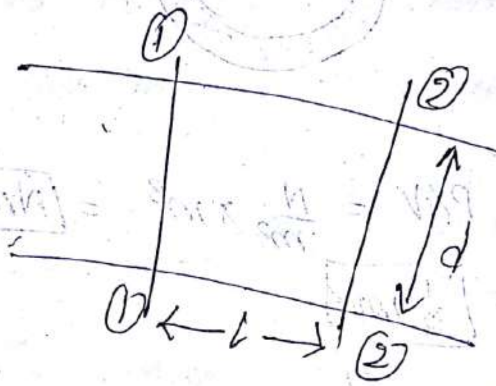
in terms of energy head.

$Q = \frac{C_d A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$



(Venturimeter)

* Loss of head due to friction



consider a uniform cross-section of pipe through which liq. flow.

Let, l = length of the pipe
d = diameter of the pipe
V = Velocity of Liq.
f = coefficient of friction

then h_f = loss of head due to friction

$$\boxed{h_f = \frac{4flV^2}{2gd}}$$

where, h_f = loss of head given by Darcy weibach.

Q. Find the loss of head due to friction in a pipe of 500 mm diameter & 1.5 km long. The velocity of water in the pipe is 1 m/sec. Take coefficient of friction is 0.005.

Ans.

Given,

$d = 500\ mm = 0.5\ m$

$l = 1.5\ km = 1500\ m$

$V = 1\ m/sec$

$f = 0.005$

$$\boxed{h_f = \frac{4 f l V^2}{2 g d}}$$

$$= \frac{4 \times 0.005 \times 1500 \times 1}{2 \times 9.8 \times 0.5}$$

$$= \frac{30}{9.8} = 3.061\ m.$$

Q. The water is flowing through a pipe having dia 20 cm & 10 cm at section 1 & 2 respectively. The rate of flow through pipe is 35 lit/sec. The section 1 is 6 m above datum & section 2 is 4 m above datum. If the pressure at section 1 is 39.24 N/cm². Find the intensity of pressure at sec. 2 ?

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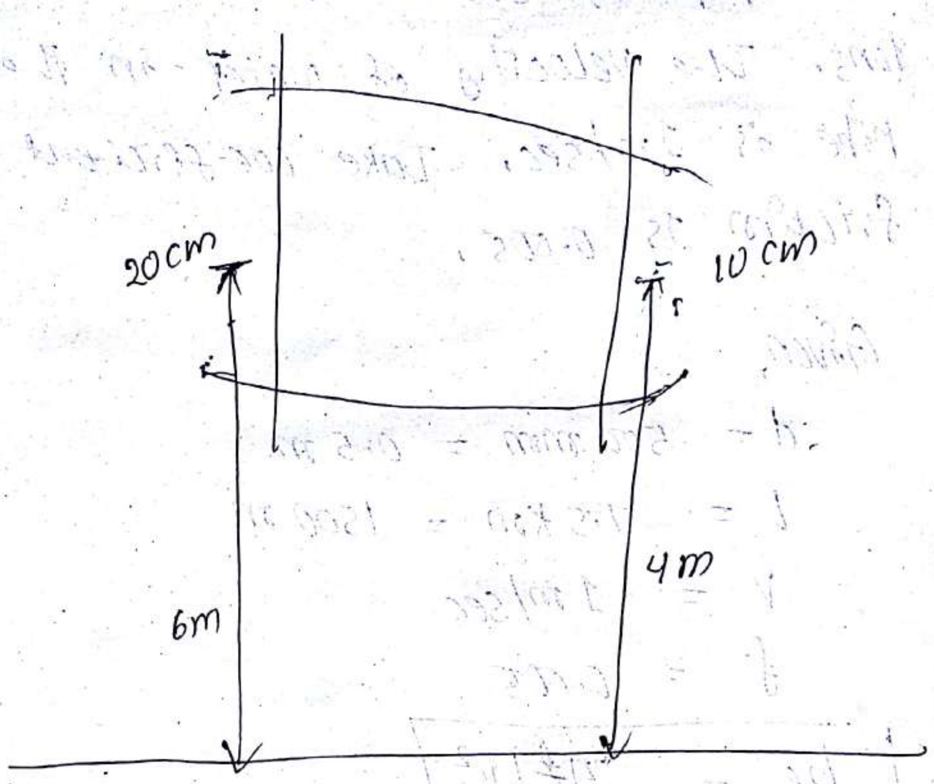


Given data,

$d_1 = 20\,cm = 0.2\,m$

$d_2 = 10\,cm = 0.1\,m$

$Q = 35\ Lit/sec = 35 \times 10^{-3}\ m^3/sec$

$Z_1 = 6m$

$Z_2 = 4m$

$P_1 = 39.24\ N/cm^2 = 39.24 \times 10^4\ N/m^2$

$P_2 = ?$

By the principle of continuity eq,

$$Q = A_1V_1 = A_2V_2$$

$$\boxed{Q = A_1V_1}$$

$$\Rightarrow V_1 = \frac{Q}{A_1} = \frac{35 \times 10^{-3}}{\frac{\pi}{4} \times (0.2)^2}$$

$$= \frac{35 \times 10^{-3}}{0.785 \times 0.04}$$

$$= \frac{35 \times 10^{-3}}{0.0314} = \boxed{1.11 \times 10^{-6}} \quad \text{— (1)}$$

$$Q = A_2 V_2$$

$$\Rightarrow V_2 = \frac{Q}{A_2} = \frac{35 \times 10^{-3}}{0.785 \times 0.01}$$

$$= \frac{35 \times 10^{-3}}{0.00785} = \boxed{4.45 \times 10^{-6}} \quad \text{-(2)}$$

Applying vornoulli at sec (1) & (2),

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

$$\Rightarrow \frac{39.24 \times 10^4}{1000 \times 9.8} + \frac{(1.11 \times 10^{-6})^2}{2 \times 9.8} + 6$$

$$= \frac{P_2}{1000 \times 9.8} + \frac{(4.45 \times 10^{-6})^2}{2 \times 9.8} + 4$$

$$\Rightarrow 40.04 + 1.23 \times 10^{-12} + 6$$

$$= \frac{P_2}{9800} + \frac{19.80 \times 10^{-12}}{19.6} + 4$$

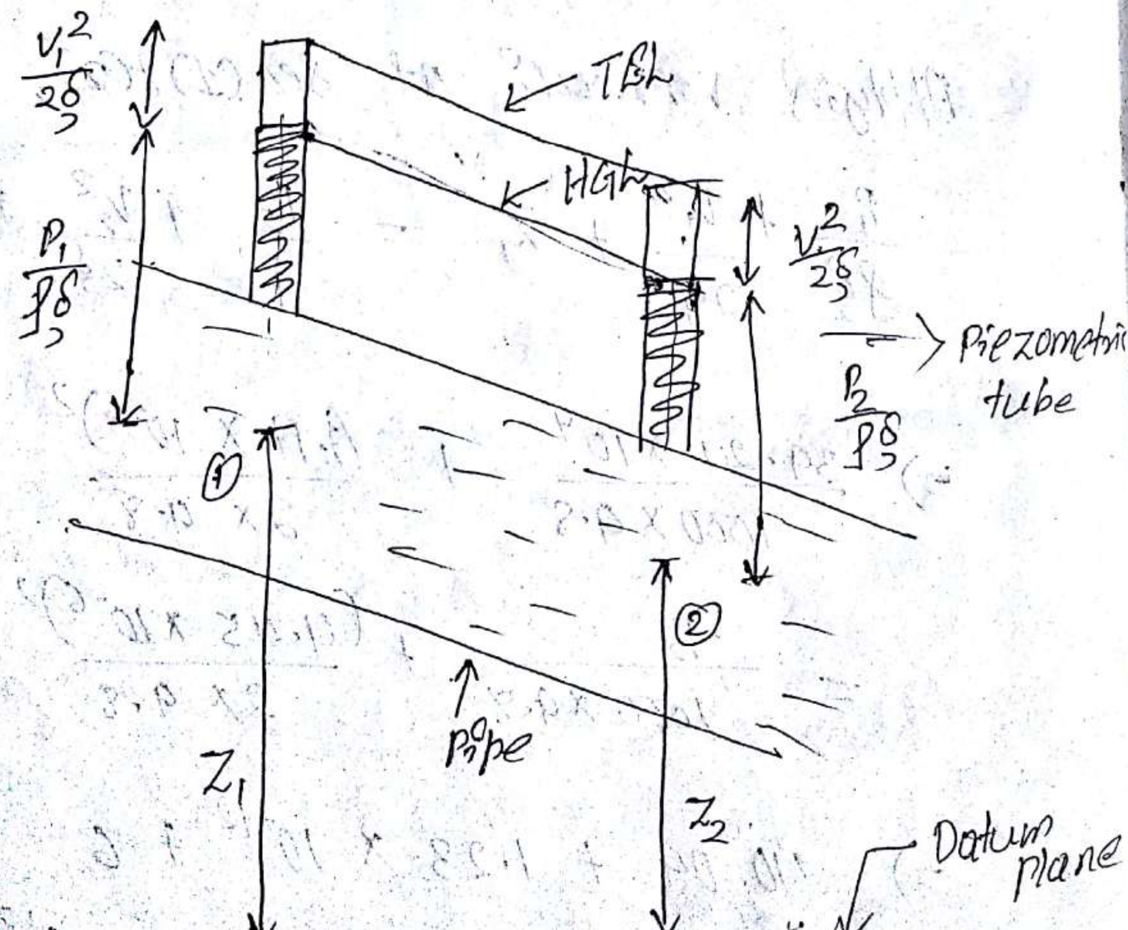
$$\Rightarrow 46 = \frac{P_2}{9800} + 4$$

$$\Rightarrow \frac{P_2}{9800} = 42$$

$\Rightarrow \quad P_2 = 42 \times 9800$

$= \boxed{4.116 \times 10^5 \ N/m^2}$

Hydraulic gradient line & total energy line



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HGL (Hydraulic Gradient line)

It is the line which join the sumation of pressure head & potential energy head betⁿ the different section of a pipe.

At. sec. 1

Pressure head $= \frac{P_1}{\rho g}$

potential energy head $= Z_1$

At. sec. 2

Pressure head $= \frac{P_2}{\rho g}$

potential E.H. $= Z_2$

$\therefore$ HGL = the line betⁿ $\left(\frac{P_1}{\rho g} + Z_1\right)$ & $\left(\frac{P_2}{\rho g} + Z_2\right)$.

TEL (Total energy line)

It is the line which join the sumation of pressure head, potential energy head & kinetic energy head betⁿ the different section of a pipe.

At. sec. 1

P.H. $= \frac{P_1}{\rho g}$

P.E.H. $= Z_1$

K.E.H $= \frac{V_1^2}{2g}$

At sec. 2

$P.H. = \frac{P_2}{\rho g}$

$P.E.H = Z_2$

$K.E.H = \frac{V_2^2}{2g}$

Total energy at 1 $= \frac{P_1}{\rho g} + Z_1 + \frac{V_1^2}{2g}$

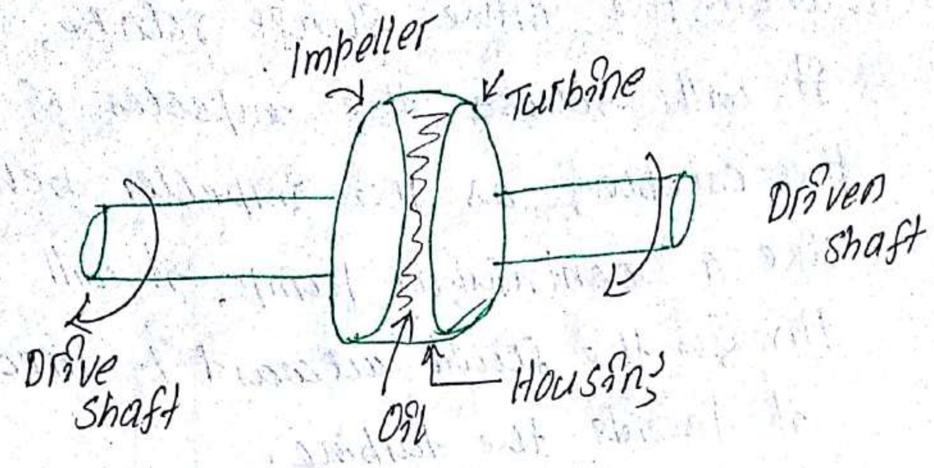
" at 2 $= \frac{P_2}{\rho g} + Z_2 + \frac{V_2^2}{2g}$

Total energy line (TEL)
= the line betn T.E. 1 & T.E. 2

$M = \frac{\rho V \rightarrow \text{vol.}}{t}$

$= \rho \frac{A.L.}{t} = \rho A.V.$

power transmission



$$P = \frac{2\pi NT}{60}$$

coupling

coupling is a device which is used to transmit the power from one shaft to another.

Hydraulic coupling

Hydraulic coupling consist of 3 parts;

(1) Housing

(2) Impeller

(3) Turbine

Housing

It protects the impeller ~~or~~ & turbine from outside damage. It contains transmission fluid.

Impeller / pump

It is connected to the drive shaft which act as a pump.

Turbine

It is connected to the output shaft.

Working principle

→ When the drive shaft rotate, it will rotate the impeller of the coupling. as the impeller behaves like a centrifugal pump, it will through the fluid outward & directs it towards the turbine.

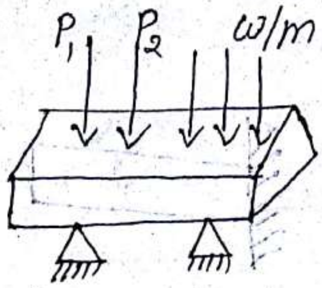
→ As the fluid strikes to the turbine blade, the turbine will also start to rotate. The direction of fluid is changed & directed towards the impeller again.

→ As the impeller speed increases, the speed of the turbine also increases. After some time the speed of both impeller & turbine becomes equal.

→ In this way the power is transmited from one shaft to another by the use of fluid.

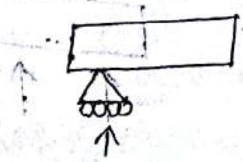
17/07/17

Beam



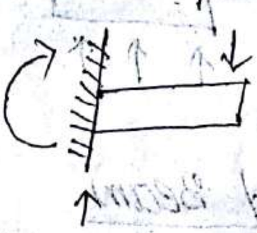
Type of support;

1. Roller support



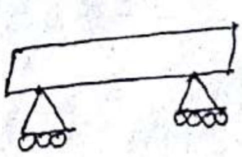
2. Hinged support

3. Fixed support

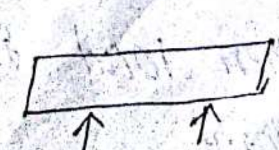


Type of Beams;

1. Simply supported beam



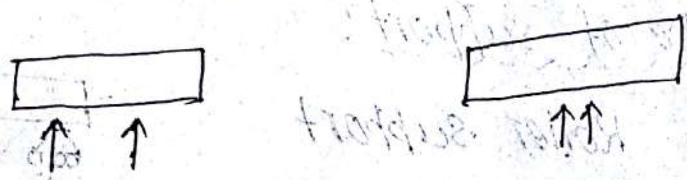
In simply supported beam either two roller or one roller and one hinge will be provided at two extreme end of the beam.



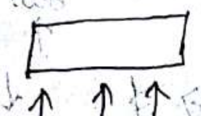
2. Cantilever Beam

In cantilever beam there will be one fixed Support at one end & other end will remain free.

3. Over-hanging Beam

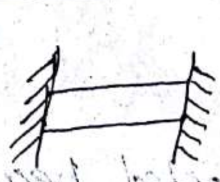


4. Continuous Beam



(more than two supports)

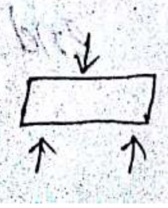
5. Fixed Beam



Types of load:

1. point load

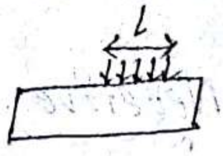
when load is concentrate at a point.



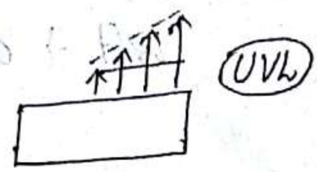
2. Uniform - distributed load

Load distributed per length

Unit : N/m

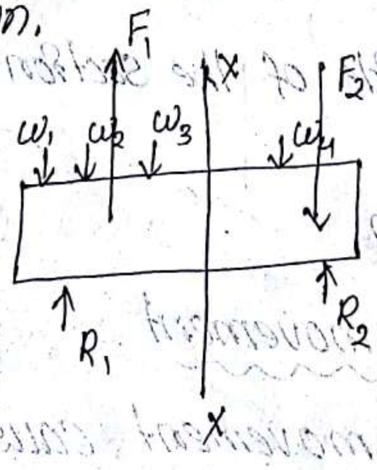


3. Uniform Varying Load



Shear force :

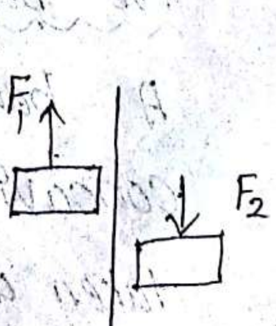
Shear force at any section of beam is the Sum of all the forces on one side of the section.



Sign convention

positive shear stress

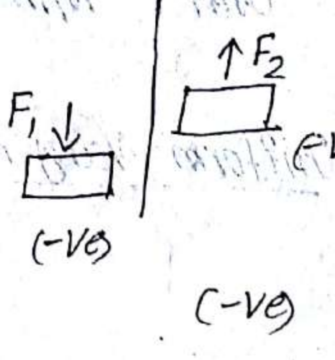
If resultant of the foreces to the left of a section is up-ward and down-ward to the right



of the section, then it is taken as positive shear stress.

Negative shear stress

Right → upward
left → downward



Bending moment

Bending moment at a section of beam is defined as the algebric sum of the moments about the section of all the forces of one side of the section.

Sign convention

+ve bending movement

A bending movement causing concavity in up-ward direction is taken as +ve bending movement.

This bending movement is known as sagging movement.

-ve bending movement

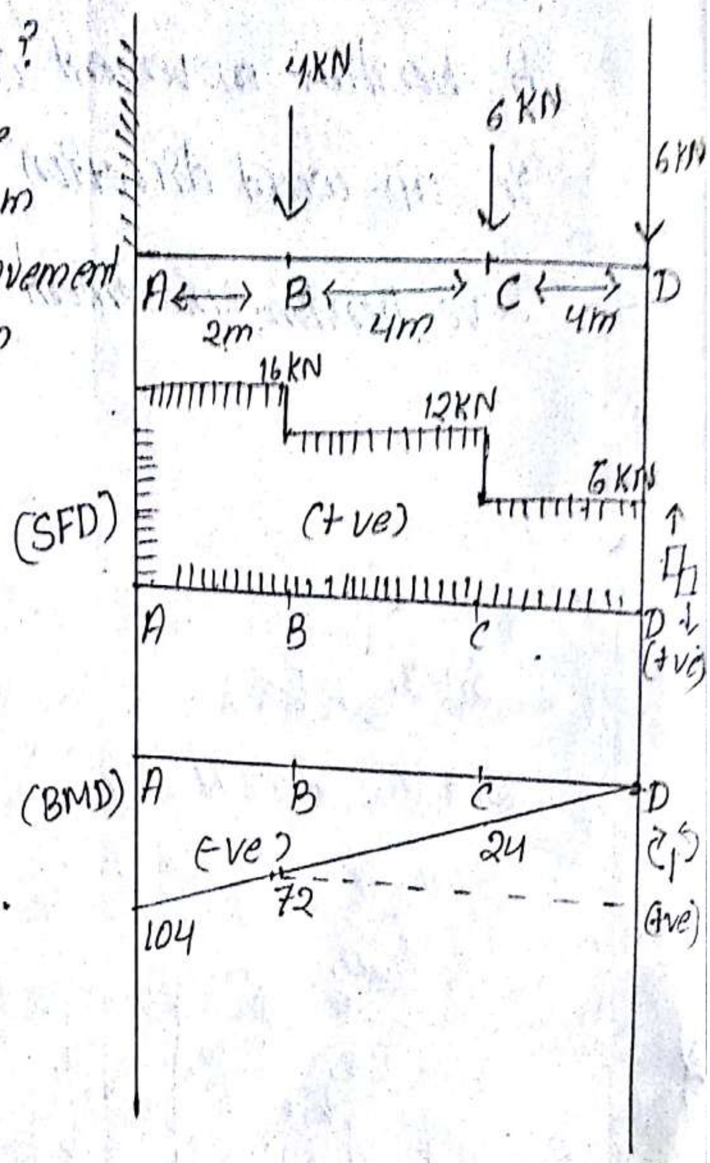
A bending movement causing conventicity in up-ward direction is taken as -ve bending movement.

Q. Problem based on cantilever beam Submitted to concentrated load.

Q. Draw SFD & BMD ?

SFD → Shear force diagram

BMD → Bending movement diagram



In section CD

There is only one constant force acting downword to the right of c.

$\boxed{F_{CD} = +6\,KN}$

In section BC

In section BC,

$F_{BC} = F_{CD} + 6\,KN$

$\Rightarrow \boxed{F_{BC} = +12\,KN}$

In Section AB

$F_{AB} = F_{BC} + 4\,KN$

$= \boxed{+ve\ 16\,KN}$

Note;-

Area under the shear force diagram is the bending movement.

Calculation of BMD;

Take a section at a distance x from the point D. Now the bending movement;

$M_x = \Sigma F x$

At point D, $x = 0$

$\boxed{M_D = F \times 0 = 0}$

At point C, $x = 4m$

$\boxed{M_C = -6 \times 4 = -24 \text{ KNm}}$

At point B, $x = 8m$

$\boxed{M_B = (-6 \times 8) + (-6 \times 4) = -72 \text{ KNm}}$

At point A, $x = 10m$

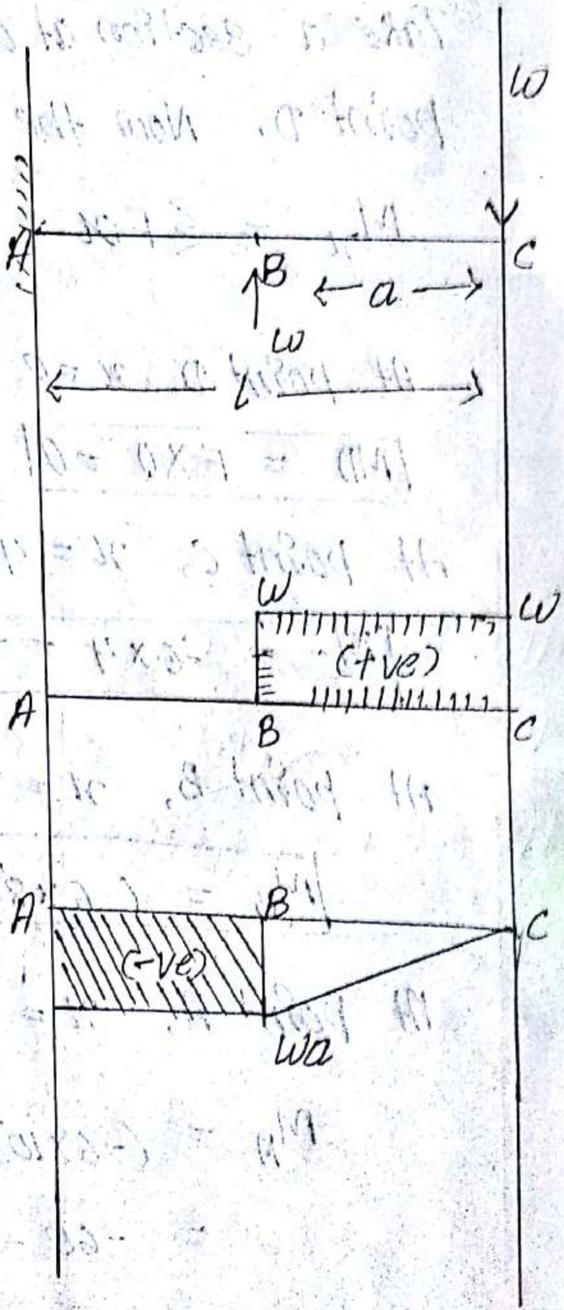
$M_A = (-6 \times 10) + (-6 \times 6) + (-4 \times 2)$

$= -60 - 36 - 8$

$= -104$

Q. A cantilever of span L is to withstand a downword acting load w at the free end and an up-ward acting load W at a distance 'a' from the free end. Draw the shear force & bending movement diagram ?

Ans.



For BC

Take a section 'AA' at a distance 'x' from point C.

$F_x = +w$ (constant)

$\boxed{F_{BC} = +w}$

For AB

$F_x = W - w = 0$

$\boxed{F_B = F_A = 0}$

BMD calculation

Section BC

$M_x = -w \cdot x$

$M_C = 0$

$M_B = -wa$

Section AB

$M_x = -w \cdot x + w(x-a)$

$= -wx + wx - wa = -wa$

Q. Draw the S.F.D & B.M.D. of the following cases of cantilever ?

(1) span of 10m with uniformly distributed load of 3KN/m for 6m starting from the free end.

Ans. Section BC

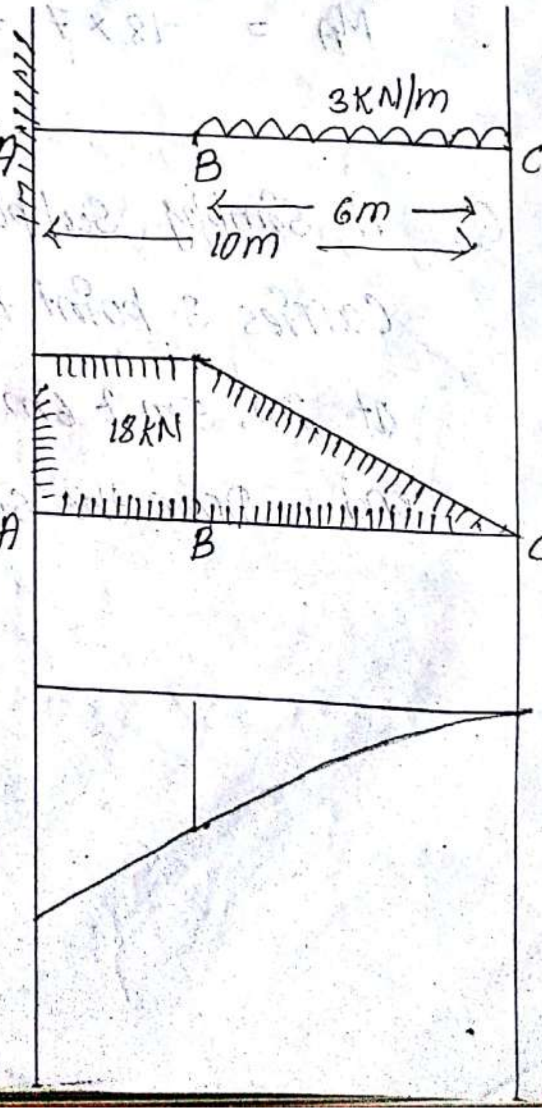
$F_x = +3x \text{KN/m} \times m$

$\boxed{= +3x \text{KN}}$

$F_C = 0 \quad (x = 0)$

$F_B = (+3 \times 6) = 18$

$(x = 6m)$



Section AB

$F_x = (+3 \times 6) = 18 \text{KN}$

$F_A = F_B = 18$

BMD

For BC

$M_x = (3 \times x) \times \frac{x}{2} = \frac{3x^2}{2} = 1.5 x^2$

↳ parabolic

$M_C = 0 \quad (x = 0)$

$M_B = 1.5 \times 6^2 = -54 \text{ KNm}$

For AB

$M_x = -3 \times 6 \text{ KN} \times (x-3)$

$= -18 \text{ KN} \times (x-3)$

$M_B = -18 \times 3 = -54 \text{ KNm}$

$M_A = -18 \times 7 = -126 \text{ KNm}$

Q. A simply supported beam of 8m length carries 3 point load of 8 KN, 4 KN & 10KN at 2m, 5m & 6m respectively from the left end. Draw the S.F.D & B.M.D ?

Ans.

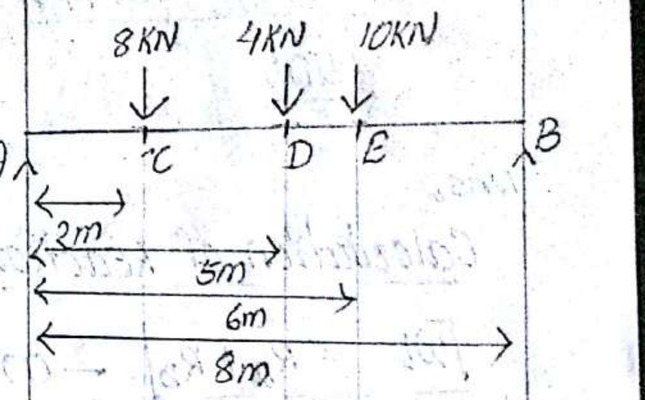
$\boxed{R_A + R_B = 22\text{ KN}}$ — (1)

$M_a = -(8\times 2) - (4\times 5)$
$\quad - (10\times 6) + (R_b \times 8)$

$\Rightarrow -16-20-60+8R_b = 0$

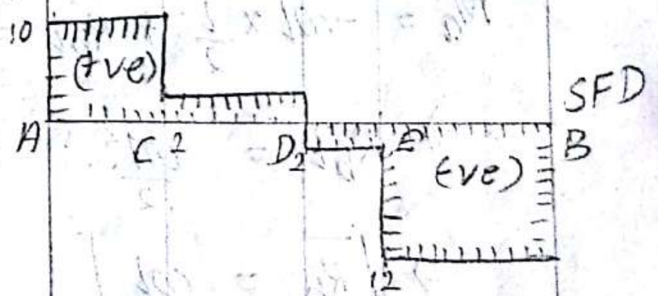
$\Rightarrow -96 + 8R_b = 0$

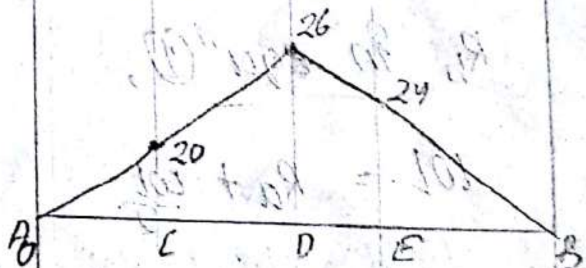
$\Rightarrow \boxed{R_b = \frac{96}{8} = 12\text{ KN}}$



$\therefore R_A + 12 = 22$ KN

$\Rightarrow R_A = (22-12)$ KN
$\boxed{= 10\text{ KN}}$





Q. Simply supported beam subjected to UDL

Ans.

Calculation of Reaction

$$\boxed{\omega L = R_a + R_b} \quad -(1)$$

$$\boxed{\Sigma M = 0} \quad -(2)$$

$$M_a = -\omega L \times \frac{L}{2} + R_b L = 0$$

$$\Rightarrow R_b L = \frac{\omega l^2}{2}$$

$$\Rightarrow \boxed{R_b = \frac{\omega l}{2}}$$

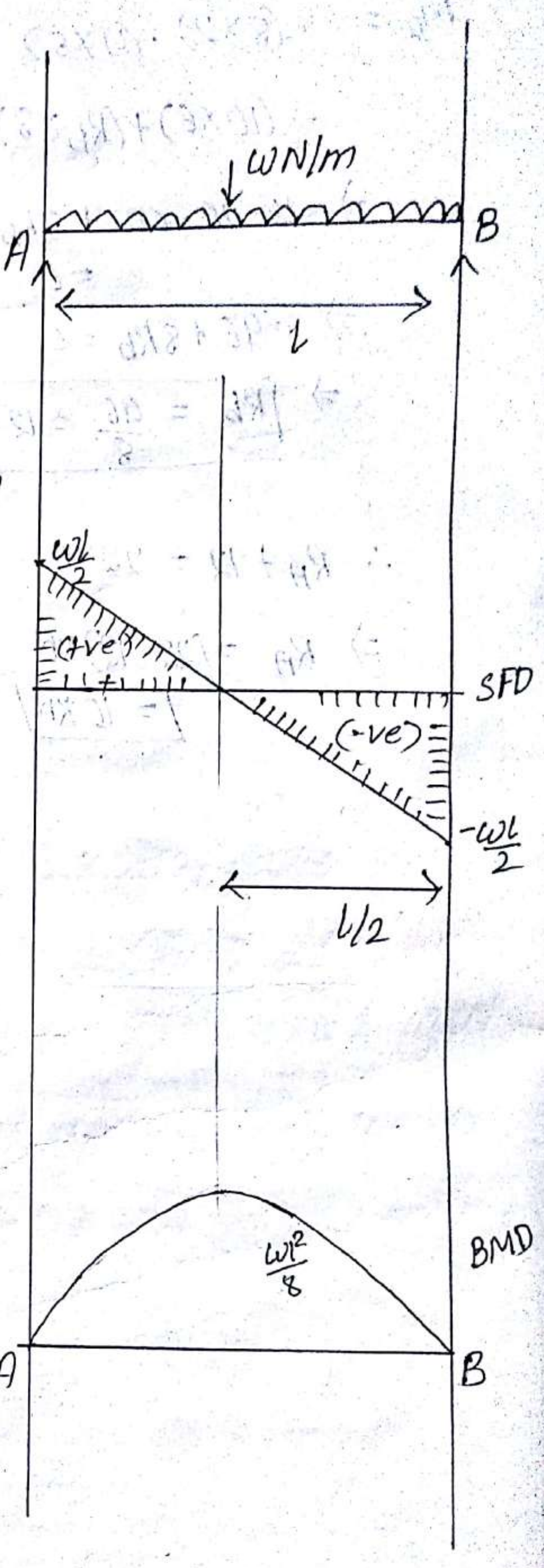
Putting the value of R_b in equ^n (1),

$$\omega L = R_a + \frac{\omega l}{2}$$

$$\Rightarrow R_a = \omega l - \frac{\omega l}{2}$$

$$= \frac{2\omega l - \omega l}{2}$$

$$= \frac{\omega l}{2}$$



Shear force calculation

In section AB;

$F_x = -\frac{wl}{2} + wx$

$F_B = -\frac{wl}{2} \quad (\because x=0)$

$F_A = \frac{wl}{2} \quad (\because x=l)$

BMD

$M = Fx$

$dm = dF\,dx$

$\Rightarrow \frac{dm}{dx} = dF$

$M_x = +R_B x - \frac{wx^2}{2}$

$M_B = 0 \quad (\because x=0)$

$M_A = 0 \quad (\because x=l)$

For max^m B.M

Shear force $F_x = 0$

$\Rightarrow -\frac{wl}{2} + wx = 0 \Rightarrow wx = \frac{wl}{2}$

$\Rightarrow x = \frac{L}{2}$

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At $x = l/2$, from B shear force will be '0'.

So, max^m bending moment

$$= M_{max} \Rightarrow M_{(x=l/2)} = +R_B x - \frac{wx^2}{2}$$

$$= R_B \frac{L}{2} - \frac{wl^2}{4} \times \frac{L}{2}$$

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

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

2 mark

* point of inflection / contraflexture

(For max^m B.M.)

Q. A 10 m long simply supported beam carries 2 point load of 10 KN & 6 KN at 2m & 9m respectively from the left end. It also has a UDL of 4 KN/m roll for the run for the length bet^n 4m & 7m from the left end. Draw the S.F. & B.M.D ?

$R_A + R_B$

$= 10\,kN + 6\,kN$

$= +12\,kN$

$\Rightarrow \boxed{R_A + R_B = 28\,kN}$ — (1)

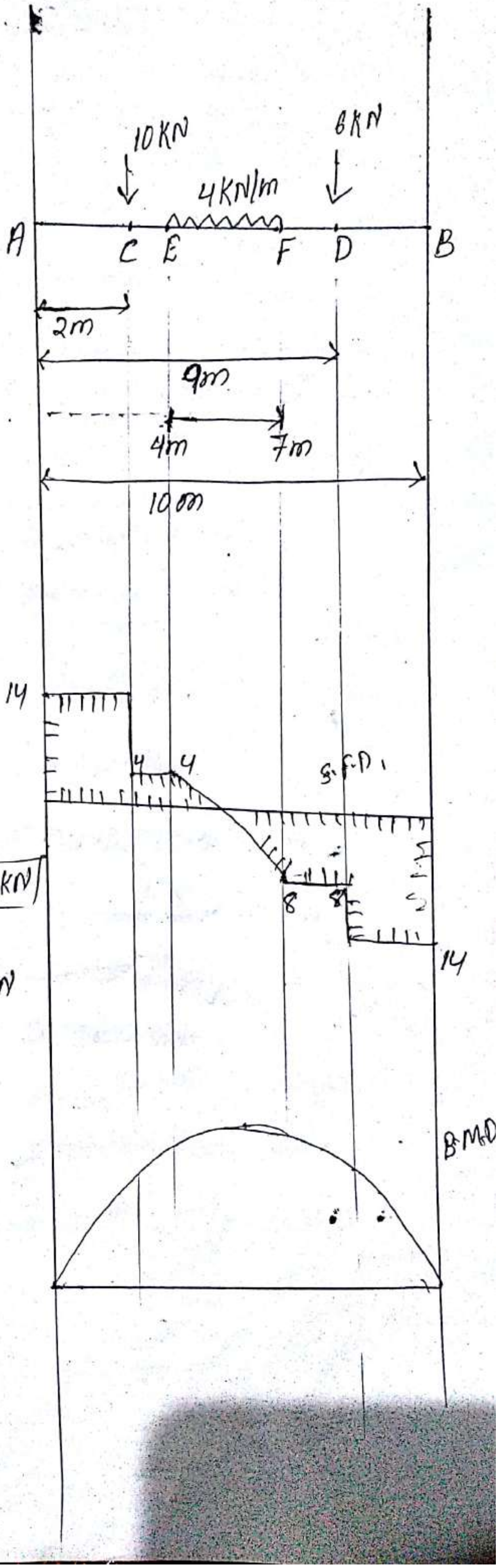
$\boxed{\Sigma M = 0}$ — (2)

$M_a = R_B \times 10 - 6\,kN \times 9 - 12\,kN \times 5.5 - 10\,kN \times 2$

$\Rightarrow 10R_B - 54\,kN - 66 - 20\,kN = 0$

$\Rightarrow R_B = \frac{140}{10} = \boxed{14\,kN}$

$\therefore R_A = 28\,kN - 14\,kN = 14\,kN$



State Bending formula

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

where,

σ = Bending stress,

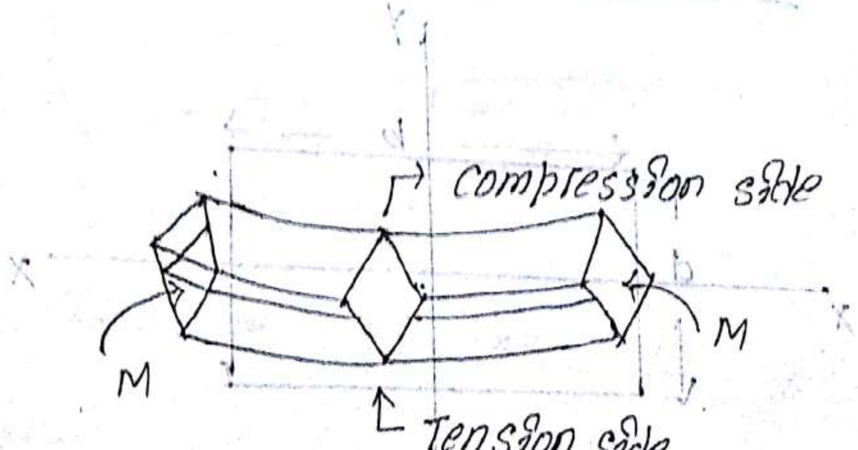
y = distance from the neutral axis,

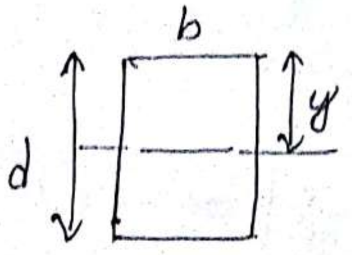
E = Young's modulus of elasticity,

R = Radius of curvature,

M = Bending moment,

I = moment of Inertia





Section modulus

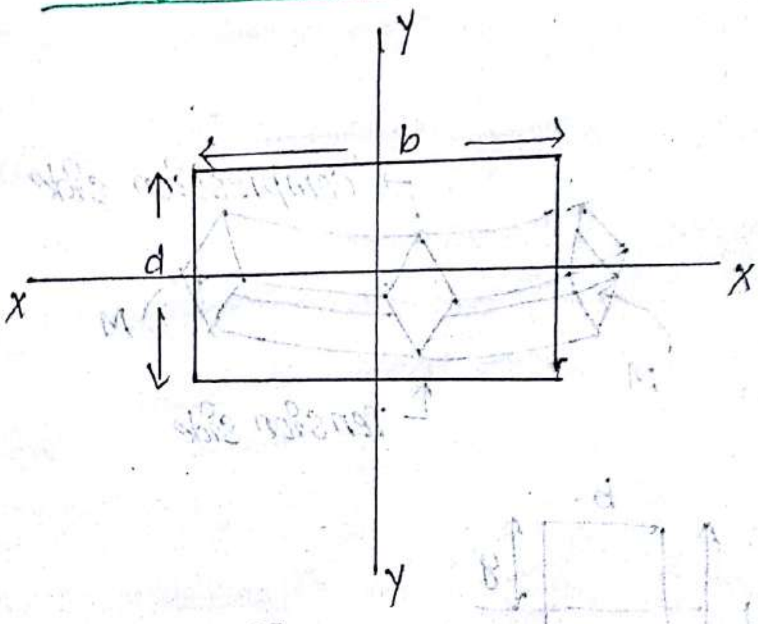
$$\boxed{\frac{\sigma}{y} = \frac{E}{R} = \frac{M}{I}} \Rightarrow \frac{\sigma}{y} = \frac{M}{I}$$

$$\Rightarrow \sigma = \frac{M}{(I/y)} = \frac{M}{Z}$$

* $Z = \frac{I}{y} \rightarrow$ section modulus

* The term $Z = \frac{I}{y}$ is known as section modulus of beam.

① Rectangular section



* $I_{xx} = \boxed{\frac{bd^3}{12}}$

* $I_{yy} = \boxed{\frac{db^3}{12}}$

* $Z_x = \frac{I_{xx}}{y} \quad (y = \frac{d}{2})$

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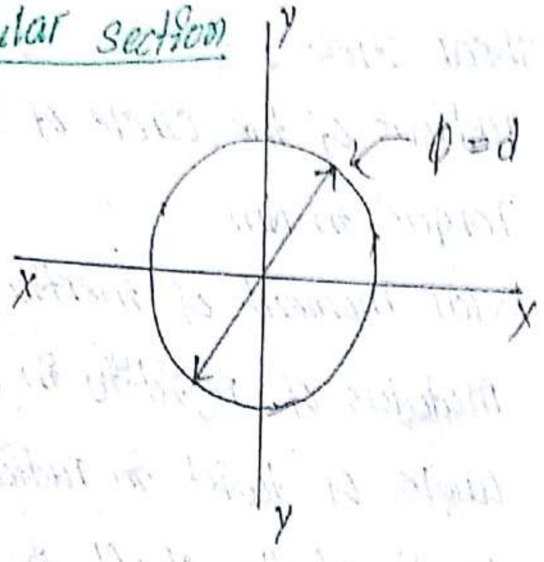
$$= \frac{bd^3}{12} \times \frac{2}{d} = \boxed{\frac{bd^2}{6}}$$

$$* \quad Z_y = \frac{I_{yy}}{x} = \boxed{\frac{db^2}{6}} \quad \left(x = \frac{b}{2}\right)$$

② Circular section



$$* \quad I_{xx} = I_{yy} = \boxed{\frac{\pi}{64} d^4}$$

$$* \quad Z_x = Z_y = \frac{I_{xx} = I_{yy}}{y}$$

$$= \frac{\frac{\pi}{64} d^4}{d/2} \quad \left(y = \frac{d}{2}\right)$$

$$= \boxed{\frac{\pi}{32} d^3}$$

$\boxed{\sigma \rightarrow \text{sigma}}$

Torsion formula

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

where,

τ = shear stress ;

r = radious of the circle of shaft in mm

T = Torque in Nm

J = polar moment of inertia

G = Modulus of rigidity in N/mm²

θ = angle of twist in radian

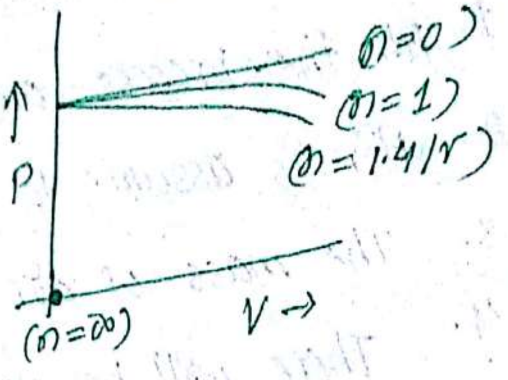
l = length of the shaft in mm .

$$\boxed{\tau = \text{Tau}}$$

4th chapter

$\boxed{PV = mRT}$

$\boxed{PV^n = \text{constant}}$



$n=0,\ P=C$
(Isobaric)

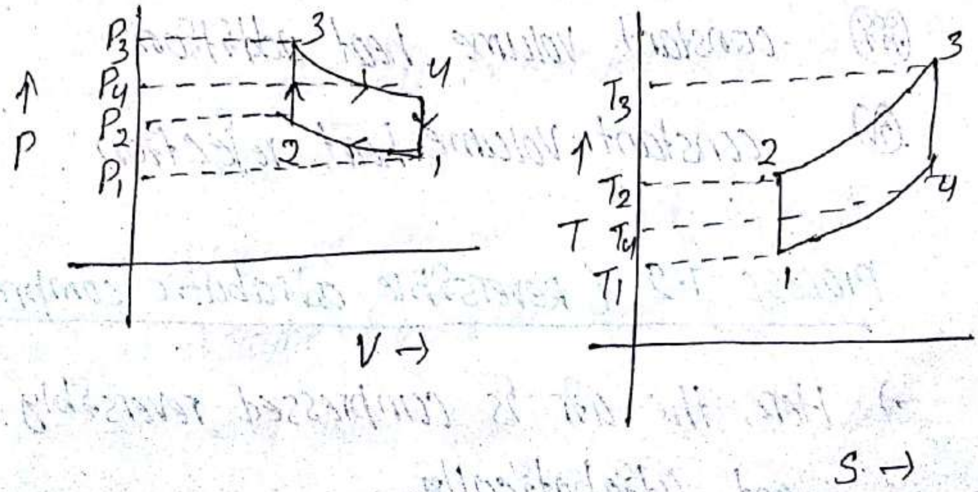
$n=1,\ PV=C$
(isothermal)

$PV^{1.4} / PV^{\gamma}$ (Adiabatic)

Constant		Name
pressure	→	Isobaric
Volume	→	Isochoric
Temp.	→	Isothermal
Heat	→	Adiabatic

Reverse adiabatic process → Entropy constant.

Otto cycle / petrol cycle / S.I (Spark Ignition) cycle



Otto

Heat is added at const. vol.