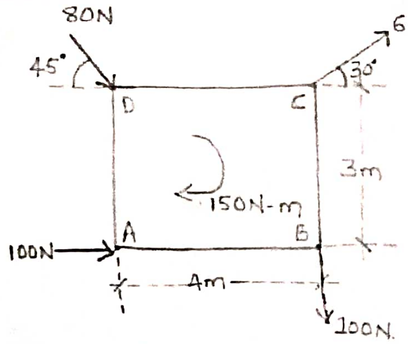
Model Question Paper-I/II with effect from 2021 (CBCS Scheme)

USN | | | | | | | | | | |

First Semester _BE_____ Degree Examination
Subject Title Elements of civil Engineering and Mechanics

TIME: 03 Hours | Max. Marks: 100

Note: 01. Answer any **FIVE** full questions, choosing at least **ONE** question from each **MODULE**.
02. Any missing data may suitable be assumed.
03.

			Marks
		Module -1	
Q.01	a	Explain briefly the scope of civil engineering in i) Irrigation engineering ii) Structural engineering	8
	b	Explain briefly application of any two smart materials in Civil engineering	6
	c	What are the requirements of good cement?	6
		OR	
Q.02	a	Explain briefly the scope of civil engineering in i) Transportation engineering ii) Water resource engineering	8
	b	Explain briefly i) RCC ii) PSC	6
	c	What are the advantages of stone construction over brick construction?	6
		Module-2	
Q. 03	a	Explain Couple and its characteristics.	6
	b	The sum of two concurrent forces P and Q is 500N and their resultant is 400N. If the resultant is perpendicular to P, find P, Q and angle between P and Q.	6
	c	Determine the resultant of the force system acting on the plate as shown in fig. Q 3(c), with respect to AB and AD.  fig. Q 3 (c)	8
		OR	
Q.04	a	State and Prove Varignon's principle of moments.	6
	b	A ladder weighing 300N is to be kept in position as shown in fig. Q4 (b). Determine the horizontal force P to be applied to keep ladder in position, assume all contact surfaces as smooth.	6

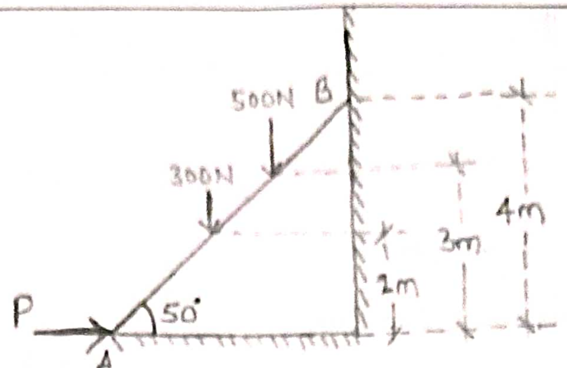


Fig. Q 4(b)

c Determine the smallest force P required to just move the bottom block if i) top block is restrained by cable AB ii) Cable AB is removed, refer fig. Q4 (c). Take μ_s = 0.30 and μ_k = 0.25. **8**

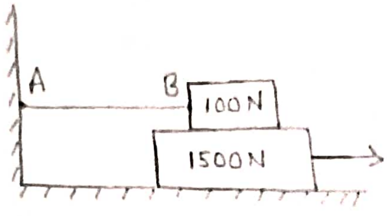


Fig Q 4 (c)

Module-3

Q. 05

a Derive an expression for moment of inertia of a triangle from first principle about its vertical centroidal axis. **10**

b Locate the centroid of the shaded area as shown in fig. Q 5(b) **10**

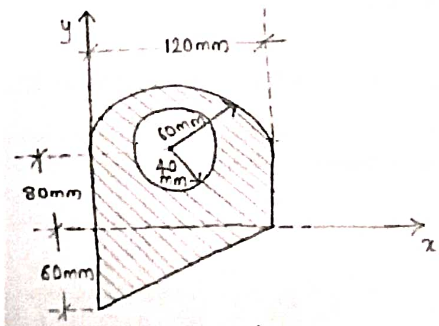


Fig Q 5(b).

OR

Q. 06

a State and prove perpendicular axes theorem **6**

b Find the centroid of the area enclosed by a semi circle of radius 'r' from first principle. **6**

c Determine the moment of inertia about X-X axis for the shaded area as shown in fig. Q 6 (c) **8**

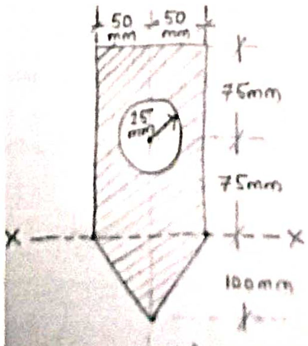


Fig Q 6(c)

		Module-4	
	a	Explain different types of loads with neat sketches.	8
	b	Analyse the truss as shown in fig Q 7(b), by methods of joints.	12

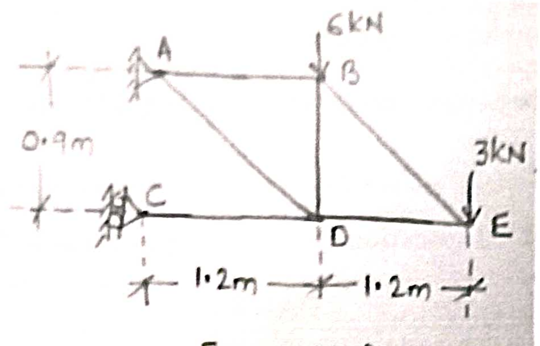


Fig. Q 7(b)

		OR	
Q. 08	a	Write a note on classification of trusses.	4
	b	Find the support reactions for the beam as shown in fig Q 8 (b).	8

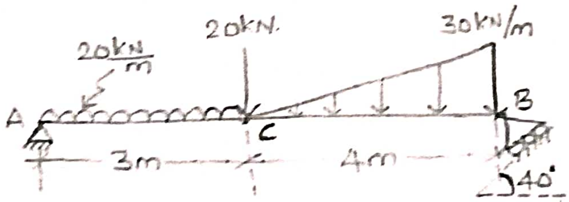


Fig. Q 8(b).

	c	A roof truss is loaded as shown in fig Q 8 (c), determine the forces in members BC, GF and CG.	8

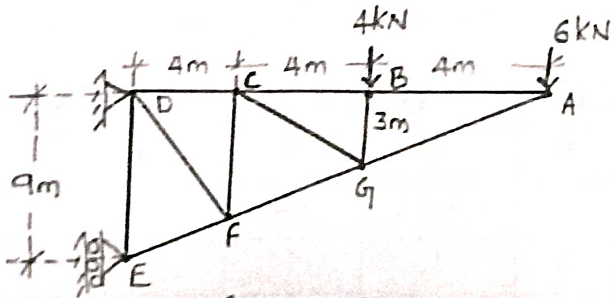


fig. Q 8(c)

		Module-5	
Q. 09	a	Define i) Time of flight ii) Horizontal range iii) Maximum Height iv) Trajectory	4
	b	A projectile is fired with a velocity of 60 m/s on horizontal plane. Find its time of flight in the following cases i) Its range is four times the maximum height ii) Its maximum height is four times the horizontal range iii) Its maximum height and horizontal range are equal.	8
	c	A stone is released from top of a tower ' h ' meter in height, it covers a vertical distance of ' h/5' meter during its last second of descend. Find the height of the tower.	8
		OR	

		State and explain D' Alembert's principle.	6
	b	The motion of a particle is defined by $x = (t+1)^2$ and $y = 4(t+1)^{-2}$ where x and y are in meters and t in seconds. Show that path of particle is part of rectangular hyperbola. Find velocity and acceleration at t = 0.	6
	c	Two cars moving in the direction are 150m apart. Car A being ahead of car B, at this instant velocity of car A is 3 m/s and constant acceleration of 1.2 m/s^2. While the velocity of car B is 30 m/s and its uniform retardation is 0.6 m/s^2. How many times do the cars cross each other? Find when and where they cross with respect to given position of car A.	8

Department: Civil
IA Test No:
Subject with Sub. Code: Elements of Civil Engg & Mechanics 21CIV14
Semester / Division:
Name of Faculty: Prof. Parvati Oni

Q.No.	Solution and Scheme	Marks
Q.1 a.	i) Irrigation Engineering – This subject deals with different sources of water on earth, estimation of total water available and water requirement, construction & maintainence of structures to tap the available sources of water, planning and building of water retaining structures such as tanks/dam construction, different irrigation schemes, flood control methodologies, completion and replenishment of water resources.	
	ii) Structural engineering – All structures constructed on earth are subjected to various types of loads. Various components of structure are expected to respond to these loads favourably and to withstand them safely. The satisfactory response of a structure requires the knowledge of material behaviour. This field includes subjects like engg. mechanics, strength of materials, structural analysis & design. It also requires the knowledge of different tools to carry out the analysis and design of different structural components.	

b. i) Piezoelectric Materials — These are the materials which possess capability to produce voltage when surface strain is introduced. These are the materials which undergo deformation when an electric field is applied across it. When it is integrated into a structural member, these materials generate an electric field in response to magnetic forces.

ii) Shape memory alloys - These are the materials which have their applications in new civil engg projects in the seismic protection of buildings. These are used in civil engg projects for repeated absorption of strain energy without permanent deformation and to resist the fatigue resistence and they are used due to their great durability and reliability in long run.

c. The requirements of a good cement are -

> Provide strength to masonry.
> Stiffens or hardens early.
> Possess good plasticity
> Excellent binding material
> Easily workable
> Good moisture resistence.

Q.2.

a. i) Transportation Engineering - The socio and economic development of a country is a function of transportation facilities available in that country. Different means of transportation include roadways, railways, airways and waterways. This field deals with the study of planning, design, construction and maintainence of different types of roadways, railways, waterways, docks, bridges, tunnels etc.

ii) Water Resource Engg - There are different sources of fresh water on this earth such as rain, ground water, streams /rivers. These waters have been harnessed and stored properly before they are utilised for different purposes such as drinking, irrigation and water power generation. This subject deals with different sources of water on earth, estimation of total water available and water requirement.

b. RCC - Reinforced Cement Concrete - It is the concrete that contains embedded steel bars, plates or fibers that strengthen the material. The capability to carry the loads by these material is magnified and because of this, RCC is extremely used in all construction. Reinforced materials are embedded in the concrete in such a way that the two materials resist the applied forces together. The compressive strength of concrete and tensile strength of steel form a strong bond to resist these stresses over a long span.

PSC (Prestressed Concrete Structure) - It is a structural material that allows for predetermined engineering stresses to be placed in members to counteract the stresses that occur when they are subjected to loading. It combines the high strength compressive properties of concrete with the high tensile strength of steel. It is commonly used for floor beams, piles and railway sleepers as well as structures such as bridges, water tanks, roofs and runways.

c. The advantages of stone construction over brick construction are.

> Stone has average compressive strength of about 104.9 MPa, proving to be a better option compared to others.
> Weather resistence - Stone masonry has the capacity to resist any effect caused by the elements of weather. In case of rain, stone does not absorb water hence there will not be any future problems.
> Durability - Stone masonry has a great advantage over other construction methods because the stone is able to withstand wear, pressure & damage.
> Maintainence - Due to its durability, the buildings constructed through stone masonry require very little maintainence as opposed to other methods.

Q.3.

a. Two forces, same in magnitude opposite in direction separated by a definite distance forms a couple.
Characteristics of couple -

> The algebraic sum of forces constituting a couple is zero.
> The algebraic sum of moment of forces constituting the couple about any point is same and is equal to moment of couple itself.
> A couple cannot be balanced by a single couple.

b. $P+Q = 500$

$P = 500 - Q$

We have

$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$ — ①

$\tan\alpha = \frac{Q\sin\theta}{P + Q\cos\theta}$ When R is ⊥r to P,

Q.No.	Solution and Scheme	Marks

$\tan 90 = \text{error}$ ie $P + Q\cos\theta = 0$ — ② $Q\cos\theta = -P$.

$\therefore$ From eqn ① $400^2 = P^2 + Q^2 + 2P(-P)$ $\therefore Q^2 - P^2 = 400$.

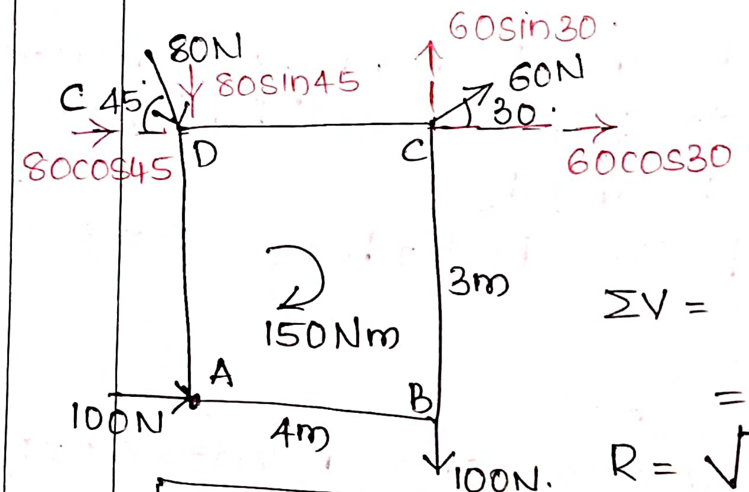
$(Q-P)(Q+P) = 400^2$ $(Q-P) \times 500 = 400^2$ $\therefore Q - P = 320$ — ③.

From eqns ② and ③,

$P = 90N$, $Q = 410N$.

$\therefore$ $410\cos\theta = -90$

$\therefore \theta = 102.68°$.



$\Sigma H =$ $60\cos30 + 80\cos45 + 100$.

$= 208.53N$

$\Sigma V = 60\sin30 - 80\sin45 - 100$

$= -126.56N$

$R = \sqrt{(\Sigma H)^2 + (\Sigma V)^2}$

$= \sqrt{208.53^2 + (-126.56)^2}$

$R = 243.93N$

$\Sigma M_A = 80\cos45 \times 3 + 60\cos30 \times 3 - 60\sin30 \times 4 + 100 \times 4$

$= 605.59$ KNm

$x = \frac{\Sigma M_A}{\Sigma V} = \frac{605.59}{-126.56} = 4.785m$

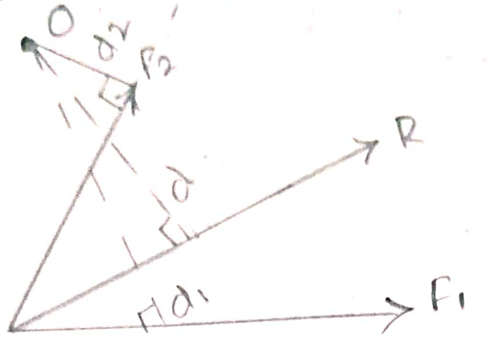
$y = \frac{\Sigma M_A}{\Sigma H} = \frac{605.59}{208.53} = 2.9m$

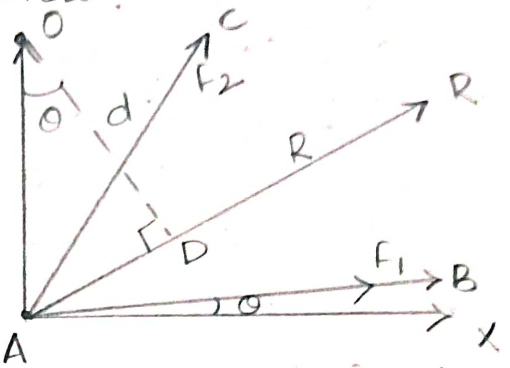
$d = \frac{\Sigma M_A}{R} = \frac{605.59}{243.93} = 2.48m$

Q.4.

a. Varignon's theorem of moment states that "The algebraic sum of moment caused by all forces about a moment centre is equal to the moment caused by the resultant of all forces about the same moment centre"

Proof-





Consider two forces F_1 and F_2 having perpendicular distances d_1 and d_2 from 'O'. Let R be the resultant of forces F_1 and F_2.

∴ We have to prove $F_1 d_1 + F_2 d_2 = R \times d$.

$R \times d = R \times OA\cos\theta$

$= OA \times R\cos\theta$

$R \times d = OA \times R_x$ —①

Similarly $F_1 \times d_1 = OA \times F_{1x}$ —② and $F_2 \times d_2 = OA \times F_{2x}$ —③

Adding equations ① and ②

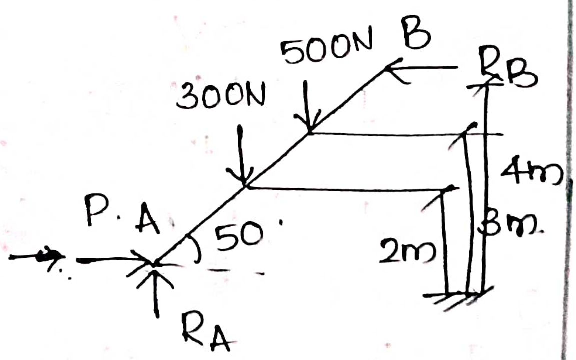
$F_1 d_1 + F_2 d_2 = OA\, F_{1x} + OA\, F_{2x} = OA\,(F_{1x} + F_{2x})$

$= OA\, R_x$ —④

Comparing equations ① and ④,

$R \times d = F_1 d_1 + F_2 d_2$ Hence proved.

b.



$\Sigma H = 0$.

$\Rightarrow P - R_B = 0. \Rightarrow P = R_B$

$\Sigma V = 0$

$\Rightarrow R_A - 300 - 500 = 0$

$R_A = 800N$

$\frac{d}{?} = \tan 50$.

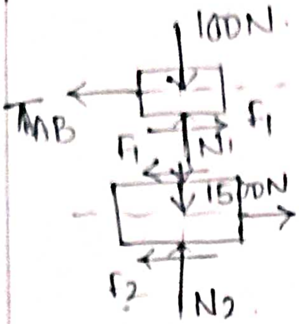
$\Sigma M_A = 0$.

$\Rightarrow 300 \times \frac{2}{\tan 50} + 500 \times \frac{3}{\tan 50} - R_B \times 4 = 0$.

$R_B = 440.52\,N$

∴ $P = 440.52\,N$.

c. i) top block is restrained by cable AB.



$\mu_s = 0.3$

$\mu_k = 0.25$

Consider block of 100 N

$\Sigma H = 0$

$\Rightarrow T_{AB} - F_1 = 0$.

$\Sigma V = 0$.

$\Rightarrow N_1 - 100 = 0$

$\boxed{N_1 = 100\,N}$

But $\frac{F_1}{N_1} = 0.3 \Rightarrow F_1 = 0.3 N_1 = 0.3 \times 100$

$\boxed{F_1 = 30N}$

Consider block of 1500 N.

$\Sigma H = 0 \Rightarrow -F_1 - F_2 + P = 0$ — ①

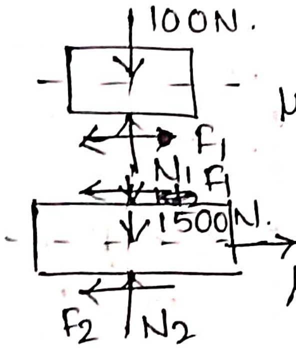
$\Sigma V = 0 \Rightarrow -1500 - N_1 + N_2 = 0. \Rightarrow -1500 - 100 + N_2 = 0$.

$\boxed{\therefore N_2 = 1600\,N.}$

But $\frac{F_2}{N_2} = 0.25 \Rightarrow F_2 = 0.25 N_2 = 0.25 \times 1600 = 400\,N$.

$\therefore$ From eqn ①, $-400 - 30 + P = 0 \Rightarrow \boxed{P = 430\,N}$

ii) When cable AB is removed.



$\mu_s = 0.3$

$\mu_k = 0.25$

Consider 100N block.

$\Sigma H = 0$.

$\Rightarrow F_1 = 0$.

$N_1 = 0$.

Consider block of 1500N. $\Sigma H = 0$

$\Rightarrow -F_1 - F_2 + P = 0 \Rightarrow P = F_2$.

$\Sigma V = 0 \Rightarrow -N_1 + N_2 - 1500 = 0 \Rightarrow N_2 = 1500\,N$.

But $\mu_k = \frac{F_2}{N_2} = 0.25 \Rightarrow F_2 = 0.25 N_2$

$= 0.25 \times 1500$

$= 375\,N$

$\therefore \boxed{P = 375\,N}$

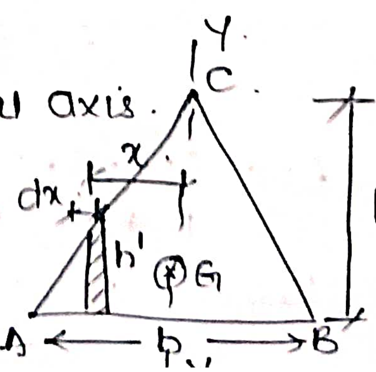
Q.5

a Let Y-Y be the vertical centroidal axis.

By similar triangles,

$\frac{h'}{h} = \frac{b/2 - x}{b/2}$ $\therefore h' = \left[\frac{b - 2x}{b}\right] h$.

$= \left(1 - \frac{2x}{b}\right) h$.



$I_{yy} = \int x^2 \, dA$ $\quad dA = h' \, dx = \left(1 - \frac{2x}{b}\right) h \, dx$

$\therefore I_{yy} = \int_0^{b/2} x^2 \left(1 - \frac{2x}{b}\right) h \, dx = \frac{h}{b} \int_0^{b} x^2 (b - 2x) \, dx$

$= \frac{h}{b} \int_0^{b/2} (x^2 b - 2x^3) \, dx = \frac{h}{b} \left[\frac{x^3}{3} b - \frac{2x^4}{4} \right]_0^{b/2}$

$= \frac{h}{b} \left[\frac{(b/2)^3}{3} \times b - \frac{2 \times (b/2)^4}{4} \right]$

$= \frac{h}{b} \left[\frac{b^4}{8 \times 3} - \frac{b^4}{8 \times 4} \right] = \frac{h}{8b} \left[\frac{b^4}{3} - \frac{b^4}{4} \right]$

$= \frac{h}{8b} \left[\frac{b^4}{12} \right]$

$$\boxed{I_{yy} = \frac{hb^3}{96}}$$

b. Rectangle ① = $A_1 = 120 \times 80$.

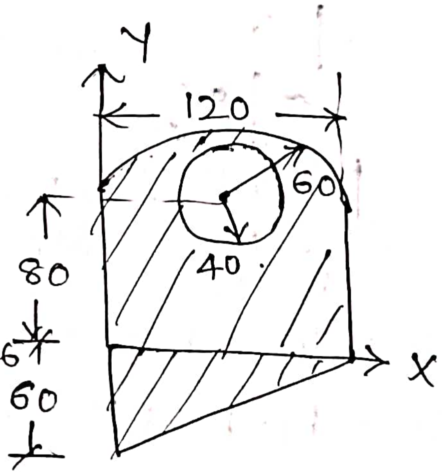
$x_1 = 60$ mm.

$y_1 = 40$ mm

Semicircle ② $A_2 = \frac{1}{2} \times \pi \times 60^2$

$x_2 = 60$mm

$y_2 = \frac{4 \times 60}{3\pi} + 80 = 105.46$



Triangle ③ $A_3 = \frac{1}{2} \times 120 \times 60 =$

$x_3 = +120/3$ $\quad y_3 = -60/3$.

Circle ④. $A_4 = -\pi \times 40^2$ $\quad x_4 = 60$ mm $\quad y_4 = 80$ mm

$\therefore \bar{x} = \frac{A_1 x_1 + A_2 x_2 + A_3 x_3 + A_4 x_4}{A_1 + A_2 + A_3 + A_4} = \frac{120 \times 80 \times 60 + 5654.86 \times 60 + 1800 \times 40 - 5026.54 \times 60}{120 \times 80 + 5654.86 + 1800 - 5026.54}$

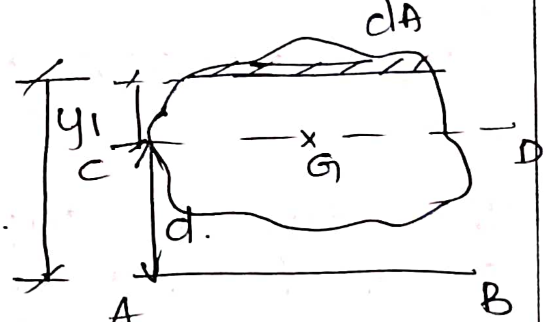
$= \underline{57 \text{ mm}}$.

$\bar{y} = \frac{A_1 y_1 + A_2 y_2 + A_3 y_3 + A_4 y_4}{A_1 + A_2 + A_3 + A_4}$

$= \frac{120 \times 80 \times 40 + 5654.86 \times 105.46 + 1800 \times (-20) - 5026.54 \times 80}{120 \times 80 + 5654.86 + 1800 - 5026.54} = 45 \text{ mm}$

Q. 6.

a. Statement - 'The moment of inertia of a body about any axis is equal to the sum of moment of inertia about the parallel axis passing through the centroid of the area and product of area and square of distance between the two parallel axes.



$$I_{AB} = \int y^2 dA$$

$$y = y_1 + d$$

$$I_{AB} = \int (y_1 + d)^2 dA$$

$$= \int (y_1^2 + 2y_1 d + d^2)\, dA$$

$$= \int y_1^2 dA + 2d \int y_1 \, dA + d^2 \int dA$$

The moment of inertia of area A about CD is

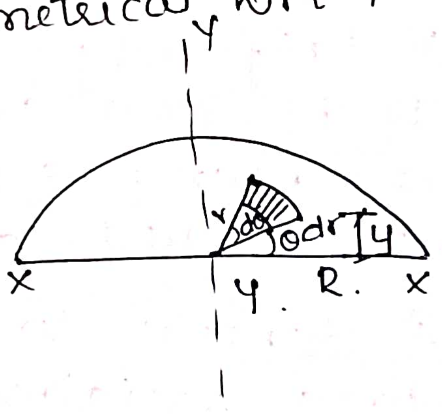
$$I_G = \int y_1^2 dA.$$

$\int y_1 dA$ is the moment of area A about its centroidal axis. As area is always symmetrical about its centroidal axis,

$$\int y_1 dA = 0 \quad \text{and} \quad \int dA = A.$$

$$\therefore I_{AB} = I_G + 0 + d^2 A = I_G + Ad^2.$$

b. Since the semicircle is symmetrical wrt Y axis $\bar{x} = 0$.



$$\bar{y} = \frac{\int y \, dA}{A}.$$

$$dA = r\, d\theta\, dr. \qquad A = \frac{1}{2} \pi R^2.$$

$$y = r\sin\theta.$$

$$\bar{y} = \frac{\iint r\sin\theta \; r\, d\theta\, dr}{1/2\, \pi R^2}.$$

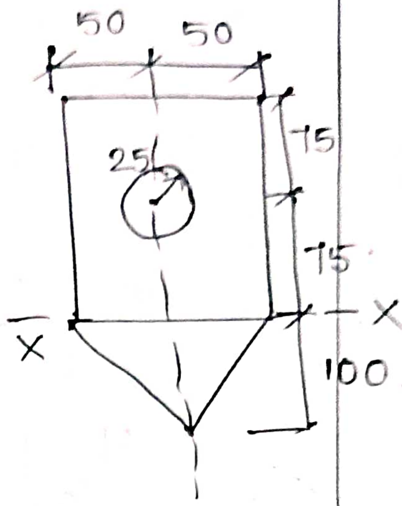
$$\int_0^R \int_0^{2\pi} r^2 \sin\theta \, d\theta\, dr = \int_0^R r^2 (-\cos\theta)_0^{2\pi} \, dr.$$

$$= \int_0^R r^2 - (-1-1)\, dr = 2\int_0^R r^2 dr = 2\left(\frac{r^3}{3}\right)_0^R$$

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

$$\therefore \bar{y} = \frac{\frac{2R^3}{3}}{\frac{1}{2}\pi R^2} = \frac{2R^3}{3} \times \frac{2}{\pi R^2} = \frac{4R}{3\pi}$$

c.



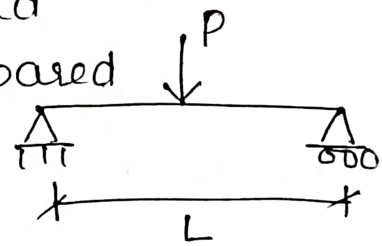
$$I_{xx} = \frac{100 \times 150^3}{3} + \frac{100 \times 100^3}{12} - \left[\frac{\pi \times 25^4}{4} + \pi \times 25^2 \times 75^2\right]$$

$$I_{xx} = 1.155 \times 10^8 \, mm^4$$

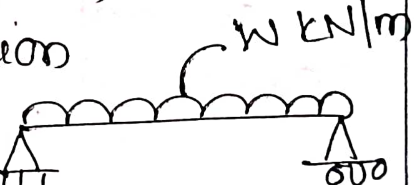
Q.7.

a. The different types of loads are

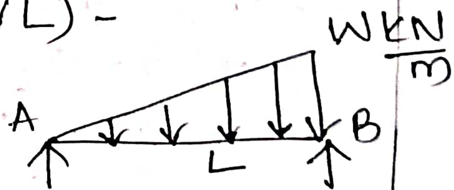
① Concentrated load – If the load acts on a very small area compared to the entire span of the beam it is called as concentrated load.



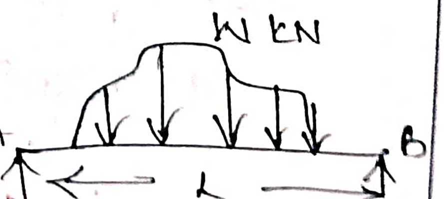
② Uniformly distributed Load (UDL) – If the load taken at any section of the beam remains same or uniform, it is called as UDL. UDL is always measured in KN/m, N/m etc.



③ Uniformly Varying Load (UVL) – If the load varies uniformly or linearly along the span then it is called as UVL.



④ General loading – If the load variation is not uniform.



b.

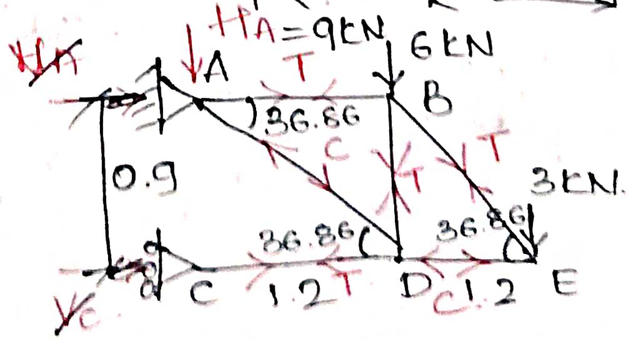
$\Sigma H = 0$

$\Rightarrow V_A + V_C = 0$.

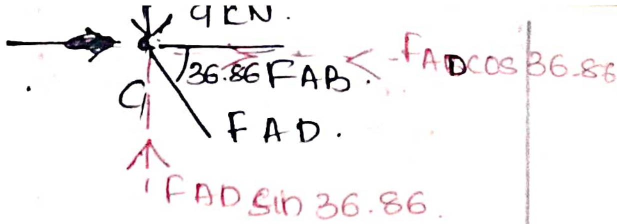
$\Sigma V = 0$.

$\Rightarrow -H_A - 6 - 3 = 0$.

$H_A = 9\,kN$



Consider joint A.



$\Sigma V = 0 \Rightarrow F_{AD}\sin 36.86 - 9 = 0$

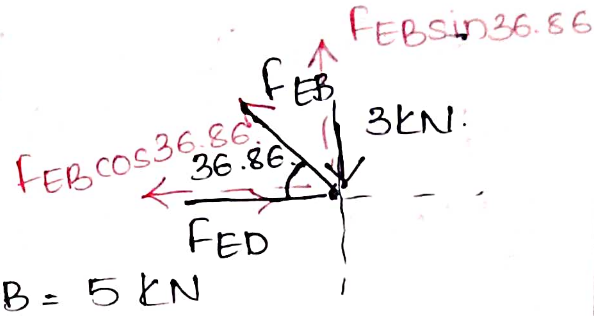
$\Rightarrow F_{AD} = 15\,kN$

$\Sigma H = 0$

$\Rightarrow F_{AB} - F_{AD}\cos 36.86 = 0$

$F_{AB} = 12\,kN$

Consider joint E.



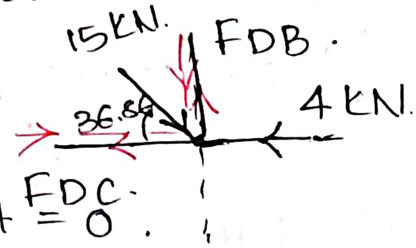
$\Sigma V = 0$

$\Rightarrow F_{EB}\sin 36.86 - 3 = 0 \Rightarrow F_{EB} = 5\,kN$

$\Sigma H = 0$

$\Rightarrow -F_{EB}\cos 36.86 + F_{ED} = 0 \Rightarrow F_{ED} = 4\,kN$

Consider joint D.



$\Sigma V = 0 \Rightarrow F_{DB} - 15\sin 36.86 = 0 \quad F_{DB} = 9\,kN$

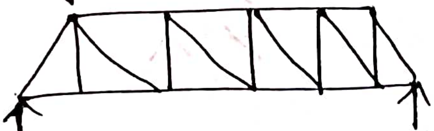
$\Sigma H = 0 \Rightarrow -F_{DC} + 15\cos 36.86 - 4 = 0$

$\Rightarrow F_{DC} = 8\,kN$

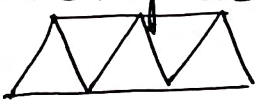
Q.8.

a. Types of trusses are –

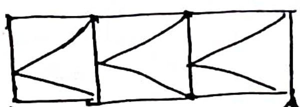
① Pratt truss – In this the vertical members are in compression while the diagonal members are in tension.



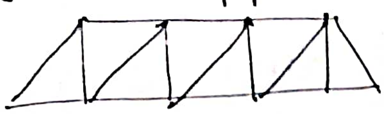
② Warren truss – This truss has ability to spread the load evenly across a no. of different members.



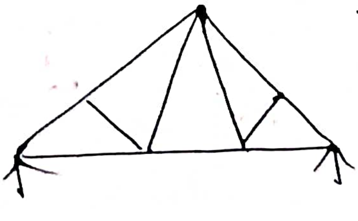
③ K truss – In this truss the vertical members have become shortened improving its resistence against buckling.



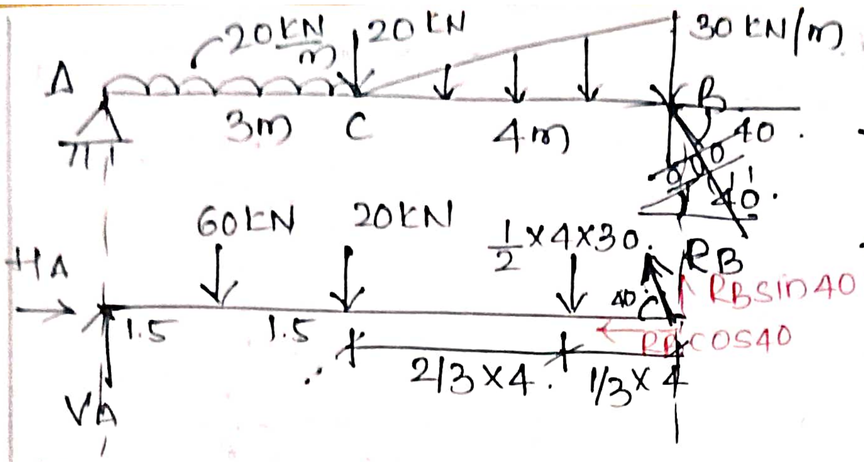
④ Howe truss – It is essentially the opposite of Pratt truss.



⑤ Fink truss –



b.



$\Sigma H = 0.$

$\Rightarrow H_A - R_B \cos 40 = 0.$

$\Sigma V = 0.$

$\Rightarrow V_A - 60 - 20 - \frac{1}{2} \times 4 \times 30 + R_B \sin 40 = 0$

$V_A + R_B \sin 40 = 140.$

$\Sigma M_A = 0 \Rightarrow 60 \times 1.5 + 20 \times 3 + \frac{1}{2} \times 4 \times 30 \times \left(\frac{2}{3} \times 4 + 3\right) - R_B \sin 40 \times 7 = 0.$

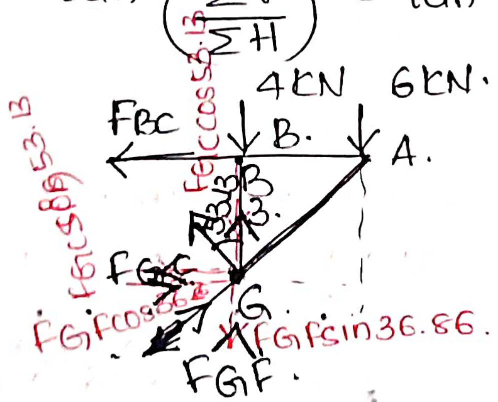
$\Rightarrow$ $\boxed{R_B = 91.37 \text{ kN.}}$ $\boxed{V_A = 81.26 \text{ kN}}$

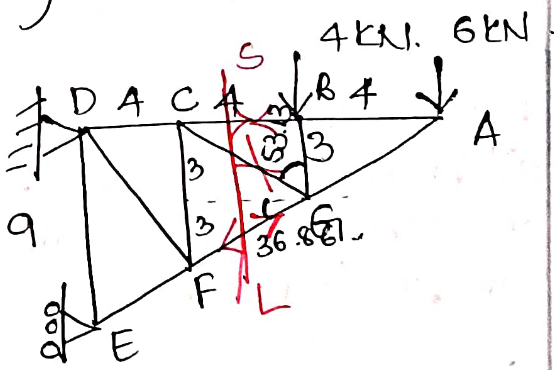
$\boxed{H_A = 70 \text{ kN}}$

$R = \sqrt{H_A^2 + V_A^2} = \sqrt{70^2 + 81.26^2} = 107.25 \text{ kN}.$

$\alpha = \tan^{-1}\left(\frac{\Sigma V}{\Sigma H}\right) = \tan^{-1}\left(\frac{81.26}{70}\right) = 49.25^\circ.$

C





$\Sigma M_G = 0 \Rightarrow 6 \times 4 - F_{BC} \times 3 = 0 \Rightarrow F_{BC} = 8 \text{ kN}.$

$\Sigma H = 0 \Rightarrow -8 + F_{GC} \sin 53.13 - F_{GF} \cos 36.86 = 0.$

$F_{GC} \sin 53.13 - F_{GF} \cos 36.86 = 8$

$\Rightarrow 0.8 F_{GC} - 0.8 F_{GF} = 8$ — (1)

$\Rightarrow F_{GC} - F_{GF} = 8$ — (1)

$\Sigma V = 0. \Rightarrow -4 - 6 - F_{GC} \cos 53.13 - F_{GF} \sin 36.86 = 0.$

$\Rightarrow -10 - 0.6 F_{GC} - 0.6 F_{GF} = 0.$

$0.6 F_{GC} + 0.6 F_{GF} = -10$ — (2).

$\Rightarrow F_{GC} + F_{GF} = -10$ — (2)

Adding (1) & (2).

$2 F_{GC} = -2. \Rightarrow$ $\boxed{F_{GC} = 1 \text{ kN.}}$

$\boxed{F_{GF} = -11 \text{ kN.}}$

Q. 9.

a. i) Time of flight – The time in which the particle is in projectile motion.

ii) Horizontal range – The maximum horizontal distance between the target and origin is called as horizontal range.

iii) Maximum height – The maximum vertical height to which the particle is in projectile motion.

iv) Trajectory – The path covered by the particle in projectile motion.

b. $u = 60\ m/s$.

$h = \frac{1}{2} g t$ $\qquad R = u \times t$.

i) When $R = 4 \times h$.

we have $R = u \times t$ $\Rightarrow 4 \times h = 60 \times t$.

$\Rightarrow 0.067h = t$.

ii) $h = 4 \times R$.

$\Rightarrow R = u \times t$. $\Rightarrow h = \frac{1}{2} g t$. $\Rightarrow 4 \times R = \frac{1}{2} \times g \times t$.

$\Rightarrow 4 \times R = \frac{1}{2} \times 9.81 \times t$ $\quad \Rightarrow t = 0.815R$.

iii) $h = R$. $\Rightarrow R = \frac{1}{2} \times 9.81 \times t$

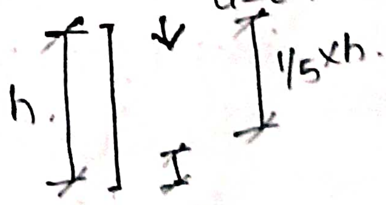
$\Rightarrow$ ~~$\frac{1}{2} g t = u \times t$~~. $\quad \therefore t = 0.204R$.

c. We have $h = ut + \frac{1}{2} g t^2$

$= 0 \times t + \frac{1}{2} \times 9.81 \times t^2$.

$h = 4.90t^2$

$g = 9.81$, $u = 0$.



If distance travelled in $(t-1)$ s is h'.

$h' = u(t-1) + \frac{1}{2} g (t-1)^2$.

$= 0 + \frac{1}{2} \times 9.81 \times (t-1)^2 = 4.9(t-1)^2$.

But $h - h' = 1/5\,h$.

$\therefore 4.9t^2 - 4.9(t-1)^2 = \frac{1}{5} \times 4.9t^2$.

$\Rightarrow t^2 - (t-1)^2 = 0.2t^2$

$\Rightarrow t^2 - t^2 - 1 + 2t = 0.2t^2$

$\Rightarrow 0.2t^2 - 2t + 1 = 0 \Rightarrow t = 5 + 2\sqrt{5}$ & $5 - 2\sqrt{5}$

$= 9.47s$ & 0.527.

$\therefore$ taking $t = 9.47s$ $h = 439\ m$

Q.10.

a. D'Alembert's principle – We have Newtons second law of motion as $F = m \times a$. We can rewrite the equation as

$$F - ma = 0.$$

The equation indicates that if a force equal to $-ma$ is added to forces acting on the particle, we get an equation that resembles equilibrium. The force $-ma$ which has same magnitude as ma but opposite direction is called inertia force. We can say the particle is in state of dynamic equilibrium. This is called D'Alembert's principle.

b. Given $x = (t+1)^2$ $\quad y = 4(t+1)^2.$

$$\therefore \quad y = \frac{4}{(t+1)^2} = \frac{4}{x}.$$

$xy = 4$ is the equation of rectangular hyperbola. Hence path of particle covered is rectangular hyperbola.

c. $S_A + S_B = 150$ $\quad u_A = 3\,m/s$ $\quad a_A = 1.2\,m/s^2$

$u_B = 30\,m/s$ $\quad a_B = 0.6\,m/s^2$

$$\left(u_A t + \frac{1}{2} a_A t^2\right) + \left(u_B t + \frac{1}{2} a_B t^2\right) = 150$$

$$\Rightarrow 3 \times t + \frac{1}{2} \times 1.2 t^2 + 30t + \frac{1}{2} \times 0.6 \times t^2 = 150$$

$$\Rightarrow 3t + 0.6t^2 + 30t + 0.3t^2 = 150$$

$$\Rightarrow 33t + 0.9t^2 = 150$$

$$\Rightarrow 0.9t^2 + 33t - 150 = 0$$

$t = 4.08\,s.$

$\therefore S_A = 22.22\,m.$ $\quad S_B = 122.4\,m.$

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