21CIV14

Model Question Papper -1

MODULE -1

1. 1 a) Explain breifely the scope of civil engineering in
i) Irrigation engineering
ii) structural engineering

→ i) Irrigation engineering: Irrigation is defined as artifical means of supply of water to crops. It is a science of planning and developing of optimal irrigation system to suit natural topographical condition

India is basically an agricultural country. The rainfall over the country is unevenly distributed over space and time. In order to get maximum yeild it is essential to supply the optimum quantity of water at appropriate time. This is possible through a systamatic irrigation system

All the irrigation projects are so planned that they increase food production, Indirect benifits are also derived from such projects, some of the advantages & indirect benefits of irrigation are.

a) Increase in yeild of the crops
b) protection against famine
c) Protection from floods
d) Raising commercial crops
e) Generation of hydroelectric power
f) Improvement in domestic & industrial water supply
g) Inland navigation

P.T.O

h) Improvement in ground water storage
i) Improvement in socio economic condition
j) Improvement in infrastructural facilities
k) Overall development of the country.

ii) Structural engineering: structural engineering division is the largest division of civil engg, since it deals with analysis & design of all type of structures.
It has the following subdivision
a) Strength and mechanics of material
b) Analysis of structure
c) Design of steel structures
d) Design of concrete structures
e) Design of masonary structures
f) Design of Timber structures
g) Design of other metal structures

1. b) Explain breifly application of any two smart materials in civil engineering.

→ The two smart materials are
1) Shape memory alloys (SMA's):
2) Magnetostrictive materials
Application of given smart materials
1) Application of SMA's

1. c) What are the requirements of good cement

→ Cement is an artifical binding material manufacturedy by burning the mixture of calcarious (containing lime calcium). silicous (containing silica) and argillaceous (containing alumina) materials in desired propotion at a very high temparature (1400°C to 1500°C). Commonly used greyish coloured cement is known as ordinary portland cement (O.P.C)

Important physical property of OPC

1. **Fitness** : Residue on 90 μ I.S. sieve should not be more than 10% by weight and specific surface should be minimum 2250 mm^2/gram

2. **soundness** : Expansion by le-chatlier's method (appartus) should not be more than 10mm

3. Minimum compressive strength : (1:3 mortar) should be 16 N/mm^2 for 3 days curring and 22 N/mm^2 for 7 days curring.

4. Minimum Tensile strength : (1:3 mortar) should be 2 N/mm^2 for 3 days curring and 2.5 N/mm^2 for 7 days curring.

5. setting time : Initial setting time should not be less than 30 minutes and final setting time should not be more than ten hours (600 minutes)

Important chemical properties of O.P.C

1) Insoluble residue should be 1.5 %

2) Magnesium oxide (MgO) should be about 6%.

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3) Sulphur as SO_3 should be about 2.75%.

4) Loss on ignition should be about 4%.

2. a) Explain breifly the scope of engineering in
   i) Transportation engineering
   ii) water resource engineering.

→ i) Transportation Engineering: Transportation engg. of division of civil engg deals with the following construction activities

a) construction of roads and highways
b) construction of railway tracks
c) construction of bridges
d) construction of airports and Runways
e) Construction of Docks and harbours

The development of transportation facilities help in quick movement of farm products and manufactured goods from one place to other.

ii) Water resource engineering: Water is one of the impor -tant natural resources and one of the basic needs of all life on the earth. The precious resource is some time scares, Some times abundant and also very unevenly distributed both in space and time. Therefore water resource engineering plays an virtual role in planning and design of water resource projects by using modern technological tools available.

P.T.O

The development of water resources involves the planning, design constuction and operation of facilities to control & economical utilization of water

water resource projects are planned to serve the following purpose

1) Irrigation, 2) Hydro power 3) flood control 4) Muncipal and industrial water supply, 5) water transport - inland navigation, port or harbours, 6) Erosion & sudimental control, 7) Fish and wild life, 8) recreational facilities 9) Drianage, 10) Artificial rain seeding, 11) Ground water development, 12) Rain water harvesting

2. b) Explain briefly i) RCC ii) PCC

→

PCC	RCC
1. High compressive strength but very less tensile Strength	1. High compressive as well as tensile strength
2. Consist of cementing (binding) material, fine and coarse aggregate only (No - reinforcement used)	2. Consist of binding material, fine aggregrate, coarse aggregrative and reinforcement in the form of wires/bars
3. used for small footings, garden pavements where tension is not developed	3. used for building (component such as beam, slabs, coloums) retaining walls, dams, roads, machine, foundations building, stair cases etc

P.T.O

PCC	RCC
4. Usually it is cast-in-situ only	4. can be cast-in-situ or pre cast/ prefabricated
5. It is used for damp proof course of plinth level, concrete flooring, levelling course below foundations and compound wall etc	5. It is extensively used for retaining walls, concrete roads, bunkers, water tanks, dams, bridge, machine and building foundations, framed structures (building with beams- coloums -slabs) etc.

2.c) what are the advantages of stone construction over brick construction ?

→ Advantages of stones as building (construction) material are:

1) Available in nature, sometimes cheaply and readily available.
2) water tight, hard, compact and tough with good strength and resistance to wear tear, abrasion.
3) Available in diffrent color, texture.
4) suitable and useful for walls, ornamental work, retaining walls, especially in rural areas.

Advantages of bricks

1) Light weight as compared to stone
2) Better strength, better fire, sound and heat resistance
3) Easy to work
4) locally manufactured available at cheap rates

5) uniformity in size helps wall construction of uniform thickness.

6) Uses are multipurpose and even broken bricks (brick-bat) are used

7) special or trained labour are not required for ordinary works.

1(b) Explain briefly applications of any two smart materials in civil engineering.

→ The different types of smart materials are:

* Shape memory alloys (SMAs)
* Magnetostrictive materials.
* Piezoelectric materials.
* Electrorheological fluids.
* Electrochromic materials.
* Smart concrete.
* Smart Building.
*

Smart materials have different properties that can be changed according to the conditions in a controlled way by external factors such as temperature, light, moisture, electric or magnetic field, p^H or chemical compounds.

These are also known as intelligent or responsive materials.

Smart materials are used in constructing smart structure which are capable of sensing minute structural crack and flaws.

Smart materials can be used for electromagnetic shielding and for enhancing electrical conductivity.

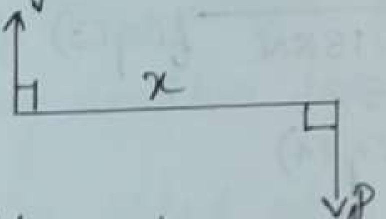
These play vital role in the construction of road pavements, as a traffic sensing recorder, and also melts ice on highway during snowfall in the ~~water~~ winter season by passing the low voltage current through it

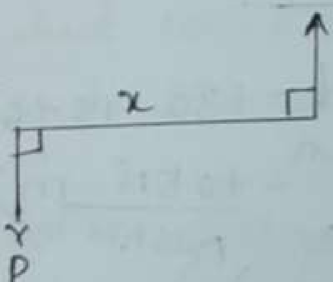
* Smart materials are used in the design of smart buildings. They are used for vibration control, noise mitigation, safety performance.
* Used for environmental control, structural health monitoring.
* Used to tranform efficiency, comfort and safety for people and assets in smart buildings.
* These reduce the effects of earthquake.
* Used in marine and rail transport applications for strain monitoring using embedded fibre optic sensor.
* Used to monitor civil engineering structure to evaluate their durability.
* Used to monitor the integrity of bridge, dams when the fibre optic sensors are embedded in the structures are utilised to identify the trouble areas.
* Used to rehabilitate the cracking and flaws of concrete when super elasticity smart materials are used as the reinforcement bars.
* Used for construction of smart bridges especially cable-stayed bridges with a wider span.

3(a) Explain Couple and its characteristics.

Ans:- Couple:- A set of two parallel forces of equal magnitude but acting in opposite direction is set to form a couple. The perpendicular distance between the lines of action of the forces is called the arm of couple. The product of one of the force with the arm of couple is called a moment of couple.

May be clockwise or anticlockwise





(+ve) Clockwise couple
Moment = P-x

Anti-clockwise Couple
Moment P.x

Characteristics of a Couple

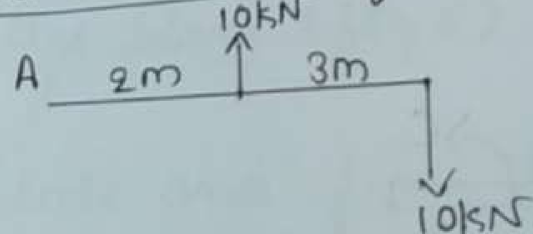


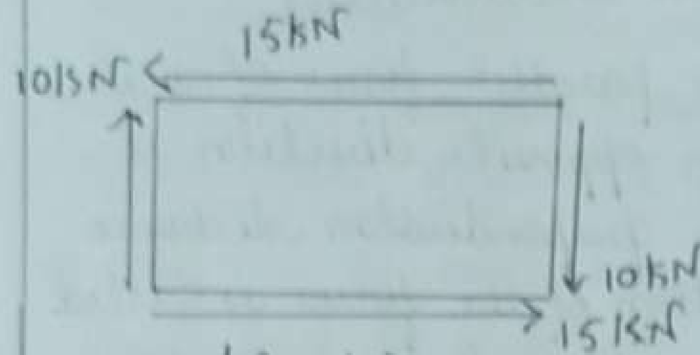
Fig (i)

Moment of Couple $= 10 \times 3 = 30$ kN-m

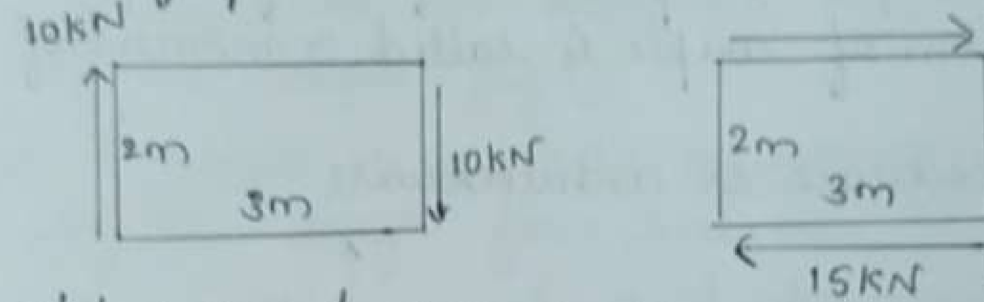
Moment of the force about A $= 10 \times 5 - 10 \times 2$

$= 30$ kN-m

$M:- 10 \times 3 - 15 \times 2$



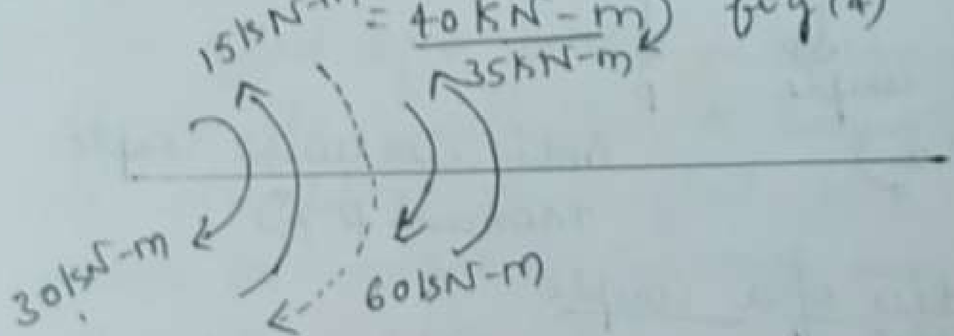
feg (2)

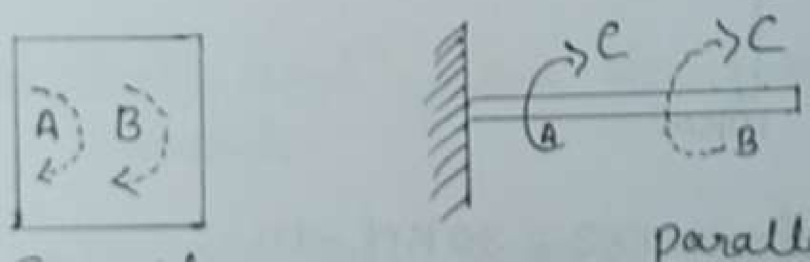


feg(3)

Net moment $= +30 - 15 + 60 - 35$

$= \underline{40\ kN\text{-}m}$ feg (4)





Same plane

parallel plane

feg(5).

i) The algebraic sum of moments of the forces forming a couple about any point in their br is constant and is equal to the moment of couple. (feg 1)

2) Two coplanar couples whose moments are equal and opposite balance each other (fig 2).

3) Any two couples whose moments are equal and of the same sighn of equivalent fig(3)

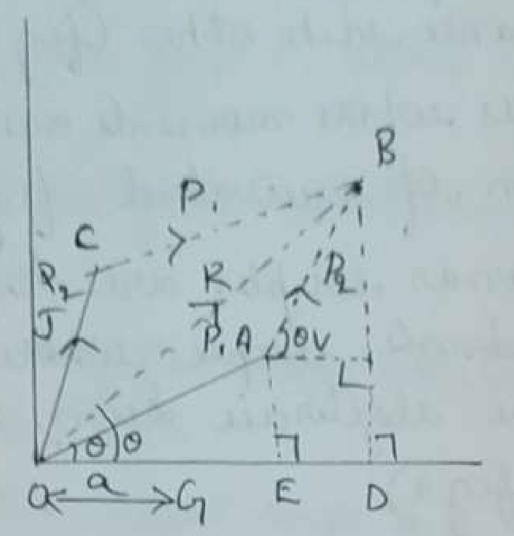
4) Any no of coplanar couples are together. equivalent to a single couple whose moment is equal to the algebraic sum. of moments of the couple (fig 4)

5) A couple cannot be equivalent or replaced by the single force but can be replaced by another equal and like couple.

6) The effect of a couple is unchanged if the couple is shifted to any other position in it's plane or shifted to a parallel plane or rotated through any angle of it's plane (fig 5)

4(a) State and prove Varignon's principle of moments.

The algebraic sum of moments of a system of coplanar force about a point in their plane is equal to the moment of their resultant force about the same point i.e $Rx = P_1x_1 + P_2x_2 + P_3x_3 + \ldots$



Consider the two force P_1 and P_2 acting at the point O with inclinations θ_1 and θ_2 respectively with r to the horizontal lying in the x y plane as shown in the above figure.

Construct the Parallelogram OABC

Let R be the resultant of P_1 and P_2 it is represented by the diagonal OB. passing through the point O.

Let θ be the inclination of R with respect to horizontal.

From B drop a perpendicular as BD to OX axis

From A drop a perpendicular AE to OX axis.

From A drop a perpendicular AF to BD as. Shown in the above figure.

Let G be the point about which the moment of the forces P_1 and P_2 and that of resultant R is required.

Let X_1, X_2, EX be the perpendicular distance from G to the forces P_1, P_2 & R respectively.

Let a be the distance from O to G.

Moment of the force P_1 above the point

$G = P_1 x_1$

Moment of the force P_2 above the point.

$G = P_2 x_2$

$\therefore$ Moment of Resultant R above the point

$G = R \times x$

from the right angle Δ^{le} OBD

$$\sin\theta = \frac{BD}{OB}$$

$$\sin\theta = \frac{BF+FD}{OB} \rightarrow (1)$$

$$= \frac{BF+FD}{OR} \rightarrow (1) \text{ eqn}$$

from the right angle Δ^{le} OEA

$$\sin\theta_1 = \frac{AE}{OA}$$

$$= \frac{AE}{P_1}$$

$$\sin\theta_1 = \frac{FD}{P_1}$$

$$FD = P_1 \times \sin\theta_1$$

from the right angle Δ^{le} ABF

$$\sin\theta_2 = \frac{BF}{AB} = \frac{BF}{P_2}$$

$$BF = P_2 \sin\theta_2$$

Substituting the values of FD & DF in eqn (1)

$$\sin\theta = \frac{P_2 \sin\theta_2 + P_1 \sin\theta_1}{R}$$

$$R\sin\theta = P_2 \sin\theta_2 + P_1 \sin\theta_1 \rightarrow (2)$$

from the right angle OGH

$$\sin\theta_1 = \frac{GH}{OG}$$

$$\sin\theta_1 = \frac{x_1}{a}$$

from the right angle $\Delta^{le}\ OGI$

$$\sin\theta = \frac{GI}{OG} = \frac{x}{a}$$

from the right angle $\Delta^{le}\ OGJ$

$$\sin\theta_2 = \frac{GJ}{OG} = \frac{x_2}{a}$$

Substituting the values of $\sin\theta_1$, $\sin\theta$ & $\sin\theta_2$ in eqⁿ ②

$$R\frac{x}{a} = P_2\frac{x_2}{a} + P_1\frac{x_1}{a}$$

$$R\frac{x}{a} = \frac{1}{a}\left(P_1x_1 + P_2x_2 + \ldots\ldots\right)$$

$$\therefore Rx = P_1x_1 + P_2x_2 + \ldots\ldots$$

$$\boxed{\therefore Rx = P_1x_1 + P_2x_2 + \ldots\ldots}$$

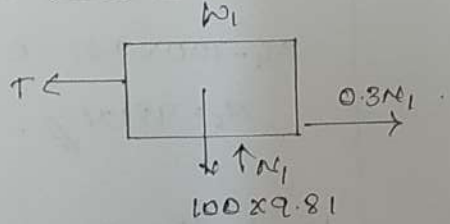
Hence the Varignon's theorem is proved.

4 c. Determine the smallest force P required to just move the bottom block (i) top block is restrained by cable AB ii) Cable AB is removed refer fig Q 4(c)

Take $\mu_s = 0.30$ and $\mu_k = 0.25$

⇒ As there is only impending motion (i.e actual motion does not take place) we have to use μ_s.

a) FBD of blocks are shown when block I is restrained by cable AB.



For I,

$\Sigma F_y = 0$

$N_1 - 100 \times 9.81 = 0$

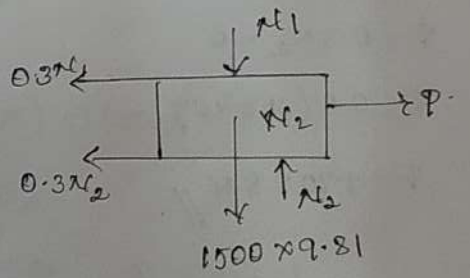
$N_1 = 981N$.

$\Sigma F_x = 0$

$-T + 0.3N_1 = 0$

$T = 0.3N_1$

$T = 294.3N$ //.



$\Sigma F_y = 0$.

$N_2 - N_1 - 1500 \times 9.81 = 0$.

$N_2 = N_1 + 14715$

$N_2 = 15696N$ //.

$\Sigma F_x = 0$

$P - 0.3N_1 - 0.3N_2 = 0$

$P - 0.3(981) - 0.3(15696) = 0$

$P = 294.3 + 4708.8$

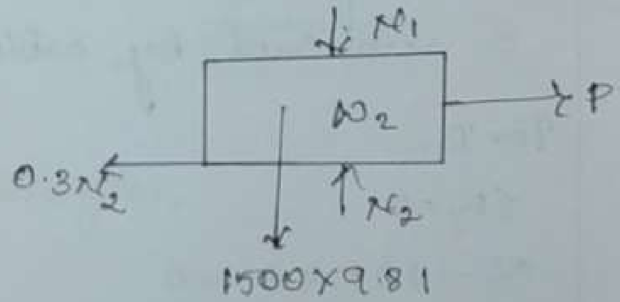
$P = 5003.1 N$ //.

b) The FBD of blocks are shown when block II is not restrained by cable AB. As there is no tendency for relative motion between W_1 and W_2 there is no friction between them.

$W_1 \rightarrow \Sigma F_y = 0$

$N_1 - 100 \times 9.81 = 0$

$N_1 = 981 N$ //.



$W_2 \rightarrow \Sigma F_y = 0$

$N_2 - 1500 \times 9.81 - N_1 = 0$

$N_2 = 14715 + 981$

$N_2 = 15696 N$

$\Sigma F_x = 0$

$P - 0.3 N_2 = 0$

$P = 0.3 (15696)$

$P = 4708.8 N$ //.

3(b) The sum of two concurrent forces P & Q is 500N and their resultant is 400N. If the resultant is perpandicular to P, find P, Q and angle between P & Q

→ let α be the angle between P & Q

Given, $P+Q = 500 \longrightarrow (1)$

$R = 400$

& $\theta = 90°$

w.k.T, $\tan\theta = \dfrac{Q\sin\alpha}{P+Q\cos\alpha}$

$\tan 90° = \dfrac{Q\sin\alpha}{P+Q\cos\alpha}$

$\infty = \dfrac{1}{0} = \dfrac{Q\sin\alpha}{P+Q\cos\alpha}$

$P+Q\cos\alpha = 0$

$Q\cos\alpha = -P \longrightarrow (2)$

w.kT, $R^2 = P^2+Q^2+2PQ\cos\alpha$

$(400)^2 = P^2+Q^2+2P(-P)$

$(400)^2 = P^2+Q^2-2P^2$

$(400)^2 = Q^2-P^2$

$(400)^2 = (Q+P)(Q-P) \Rightarrow (400)^2 = (500)(Q-P)$

$Q-P = 320 \longrightarrow (3)$

From eq^n (1) & (3), $\underline{P = 90N}$, $\underline{\underline{Q = 410N}}$

From eq^n (2), $410\cos\alpha = -90$

$$\boxed{\alpha = 102.68°}$$

3(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.

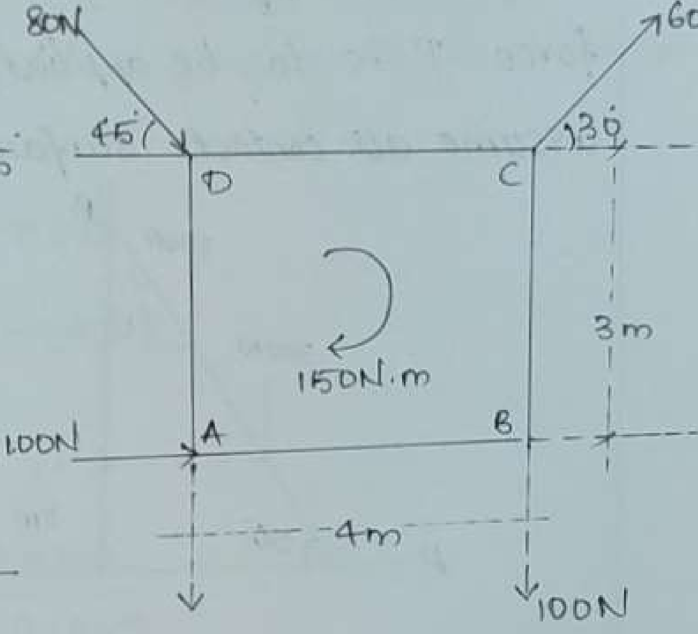


Fig Q 3(C).

ΣF_x

$= 100 + 60\cos 30 + 80\cos 45$

$\Sigma F_x = 208.53\,N$

$\Sigma F_y =$

$-100 + 60\sin 30 - 80\sin 45$

$\Sigma F_y = 126.5\,N \downarrow$

$R = \sqrt{(208.53)^2 + (126.5)^2}$

$R = 243.89\,N.$

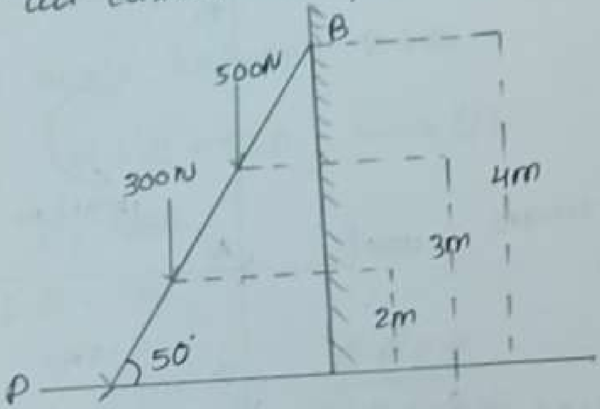
$\Sigma M_{AB} = 80\cos 45 \times 3 - 60\sin 30 \times 4 + 60\cos 30 \times 3 + 100 \times 4 + 150.$

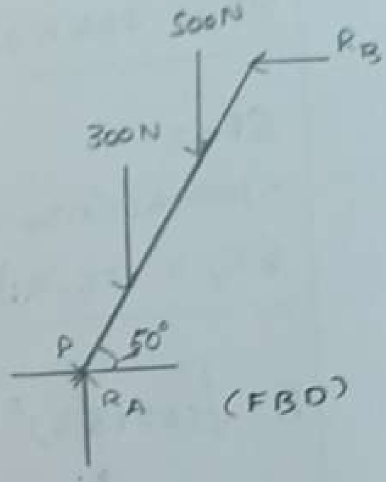
$= 755.5\,N\cdot m.$

$\Sigma M_{AD} = -60\sin 30 \times 4 + 100 \times 4 + 100 \times 3 + 150.$

$= 730\,N.m.$

4(b) A ladder weighing 300N is to be kept in position as shown in fig Q4(b). Determine the horizontal force P is to be applied to keep ladder in position assume all contact surfaces as smooth





$\Sigma F_y = 0$

$$R_A - 300 - 500 = 0$$

$$R_A = 800\ N$$

$\Sigma F_x = 0$

$$P - R_B = 0$$

$$P = R_B$$

$\Sigma M_A = 0$

$$-R_B \times 4 + 500 \times \left[3 \times \frac{1}{\tan 50}\right] + 300 \times \left[2 \times \frac{1}{\tan 50}\right] = 0$$

$$4R_B = 1762.05$$

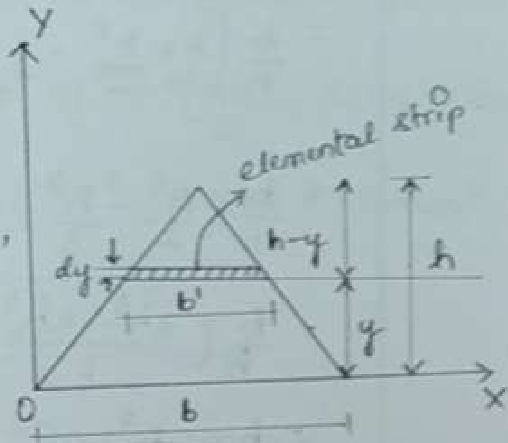
$$R_B = 440.5\ N$$

$$P = 440.5\ N \qquad (\because R_B = P)$$

Module - 03.

5.(a) Derive an expression for moment of inertia of a triangle from first principle about its vertical centroidal axis.

→ Consider a triangle of base width 'b' & height 'h'.



Consider an elemental strip of width 'b'' & thickness dy at a distance of 'y' from the base (OX axis) as shown in figure.

Width of the strip = b'

From the property of similar triangles,

$$\frac{b'}{b} = \frac{h-y}{h}$$

$$\therefore b' = \left(\frac{h-y}{h}\right) b$$

Area of the elemental strip (Consider as a rectangle)

$$= b' \times dy$$

$$= \left(\frac{h-y}{h}\right) b \cdot dy$$

Moment of area of the elemental strip about OX axis

$$= \left(\frac{h-y}{h}\right) b \times dy \times y$$

$\therefore$ Total moment of area of elemental strips about OX axis

$$= \int_0^h b\left(\frac{h-y}{h}\right) \cdot dy \cdot y$$

$$= \frac{b}{h}\int_0^h y(h-y) \cdot dy$$

$$= \frac{b}{h}\int_0^h (hy - y^2)\,dy$$

$$= \frac{b}{h}\left[\frac{hy^2}{2} - \frac{y^3}{3}\right]_0^h$$

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

$$= \frac{b}{h}\left(\frac{h^3}{2} - \frac{h^3}{3}\right)$$

$$= \frac{b}{h}\left(\frac{3h^3 - 2h^3}{6}\right)$$

$$= \frac{b}{h} \times \frac{h^3}{6}$$

$$= \frac{bh^2}{6} \text{ ——— (1)}$$

Total area of the triangle $= \frac{1}{2}bh$.

Let $\bar{y}$ be the centroidal height of the triangle from base (ox axis), Moment of total area $= \frac{1}{2}bh.\bar{y}$ ——— (2).

Applying Varignon's theorem (Principle of moments),

i.e (2) = (1).

$$\frac{1}{2}bh\bar{y} = \frac{bh^2}{6} \Rightarrow \bar{y} = \frac{2bh^2}{6bh} = \frac{2h}{6}.$$

$\therefore \boxed{\bar{y} = \frac{h}{3}}$ wrt base ox axis.

$\Rightarrow \boxed{\bar{y} = \frac{b}{3}}$ wrt vertical centroidal axis.

5(b)

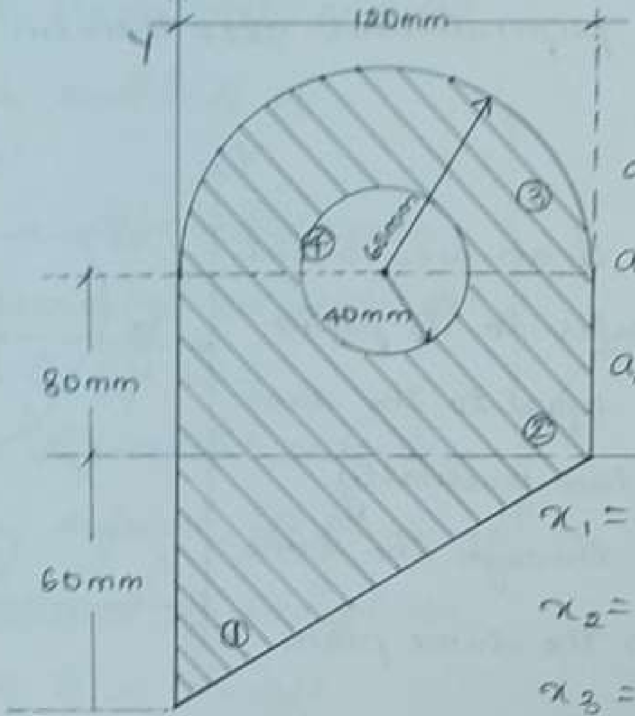
m^2

m^2

m^2

m

5(b) Locate the centroid of the shaded area as shown in fig Q5(b)



$a_1 = \frac{1}{2} \times 120 \times 60 = 3200 mm^2$

$a_2 = l \times b = 120 \times 80 = 9600 mm^2$

$a_3 = \frac{\pi r^2}{2} = \frac{\pi (60)^2}{2} = 5654.86 mm^2$

$a_4 = \pi r^2 = 5026.548 mm^2$.

$x_1 = \frac{120}{3} = 40 mm$.

$x_2 = 120/2 = 60 mm$.

$x_3 = 60 mm$, $x_4 = 60 mm$.

$y_1 = 60/3 = 20 mm$,

$y_2 = 80/2 = 40 mm$.

$y_3 = 80 + 4r/3\pi = 80 + \frac{4(60)}{3\pi} = 105.46 mm$

$y_4 = 80 mm$.

$$\bar{x} = \frac{a_1 x_1 + a_2 x_2 + a_3 x_3 - a_4 x_4}{a_1 + a_2 + a_3 - a_4}$$

$$= \frac{3200(40) + 9600(60) + 5654.869(60) - 5026.548(60)}{3200 + 9600 + 5654.866 - 5026.548}$$

$\bar{x} = 55.233 mm$.

$$\bar{y} = \frac{a_1 y_1 + a_2 y_2 + a_3 y_3 - a_4 y_4}{a_1 + a_2 + a_3 - a_4}$$

$$= \frac{3200(20) + 9600(40) + 5654.866(105.464) - 5026.548(80)}{3200 + 9600 + 5654.866 - 5026.548}$$

$\bar{y} = 47.828 mm$.

OR

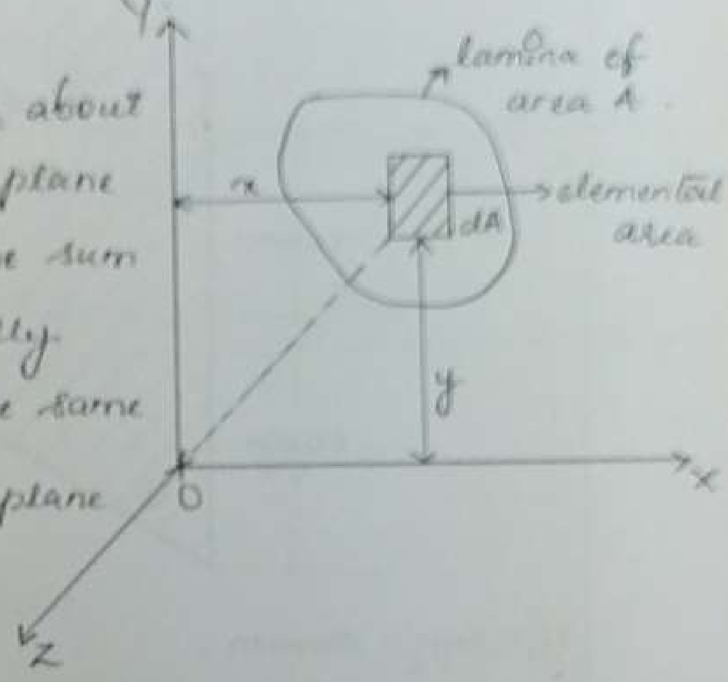
6 (a) State and prove perpendicular axes theorem

→ ~~Consider a lamina~~

Statement:

Moment of inertia of an area about an axis perpendicular to its plane at any point O is equal to the sum of MI about any two mutually perpendicular axis through the same point O & lying in the same plane of area

i.e $I_{ZZ} = I_{XX} + I_{YY}$.



Consider a lamina of total area A lying in the XY plane & ⊥ to ZZ axis as shown in figure.

Consider elemental area dA at a ⊥ distance of 'r' from O.

Let x & y be the co-ordinates of the elemental area dA from YY and XX axis shown in figure.

MI of elemental area about ZZ axis = $dA r^2$.

∴ MI of the lamina about ZZ axis,

$$I_{ZZ} = \int dA\, r^2$$

$$I_{ZZ} = \int dA\,(x^2 + y^2) \qquad [\because r^2 = x^2 + y^2]$$

$$I_{ZZ} = \int x^2\, dA + \int y^2\, dA.$$

$$\therefore \underline{I_{ZZ} = I_{YY} + I_{XX}}$$

6 (b) Find the centroid of the area enclosed by a semi circle of radius 'R' from first principle.

→ Consider a semicircle of radius 'R'.
Consider a differential sector $O'AB$ subtending an angle '$d\theta$' as shown in fig (a).
Since the differential sector is an elementary segment, its base AB is considered as straight, so that $O'AB$ is a triangle.

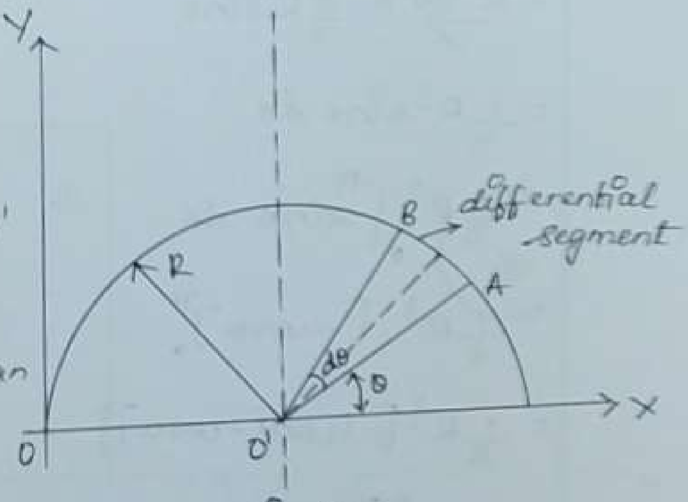


fig (a).

Base width of elementary segment $AB = R.d\theta$.
Area of the elementary segment as

$$\Delta^{le}\ O'AB = \frac{1}{2} \times base \times height$$
$$= \frac{1}{2} \times AB \times R$$
$$= \frac{1}{2} \times R d\theta \times R$$
$$= \frac{R^2 d\theta}{2}.$$

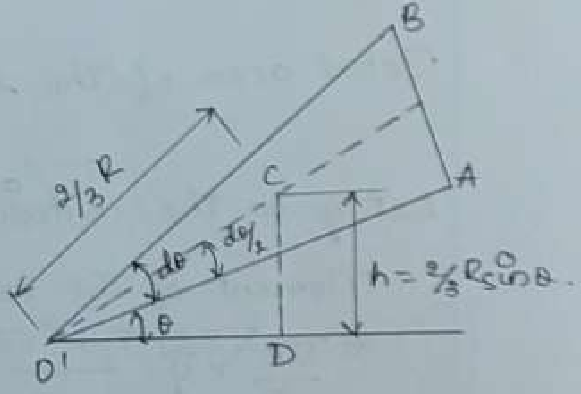


fig (b).

From fig (b), from right angled triangle $O'DC$,

$O'C = 2/3 R$.

$D\hat{O'}C = \theta + d\theta/2 \approx \theta$ $\quad$ [$\because d\theta/2$ = too small]

$$\therefore \sin\theta = \frac{DC}{O'C} = \frac{h}{2/3 R}$$

$$h = \frac{2}{3} R \sin\theta.$$

Moment of area of the elementary segment about OX axis

= area of elementary segment × perpendicular distance

$= \frac{R^2 d\theta}{2} \times \frac{2}{3} R \sin\theta$

$= \frac{1}{3} R^3 \sin\theta \cdot d\theta$

$= \frac{1}{3} R^3 \int_0^{\pi} \sin\theta \cdot d\theta$

$= \frac{1}{3} R^3 \cdot \left[-\cos\theta\right]_0^{\pi}$

$= \frac{1}{3} R^3 \left[-(\cos\pi - \cos 0)\right]$

$= \frac{1}{3} R^3 \left[-(-1) + 1\right]$

$= \frac{2}{3} R^3$ ——— (1)

Total area of the semi circle $= \frac{\pi R^2}{2}$.

Let $\bar{y}$ be the centroidal height of the semicircle from OX axis.

∴ Moment of the total area of the semicircle about OX axis

$= \frac{\pi R^2}{2} \times \bar{y}$ ——— (2).

Applying Varignon's theorem (Principle of moments)

i.e (2) = (1).

$$\frac{\pi R^2}{2} \bar{y} = \frac{2}{3} R^3$$

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

$\boxed{\bar{y} = \frac{4R}{3\pi}}$ and $\boxed{\bar{x} = R}$ (wrt OY axis)

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

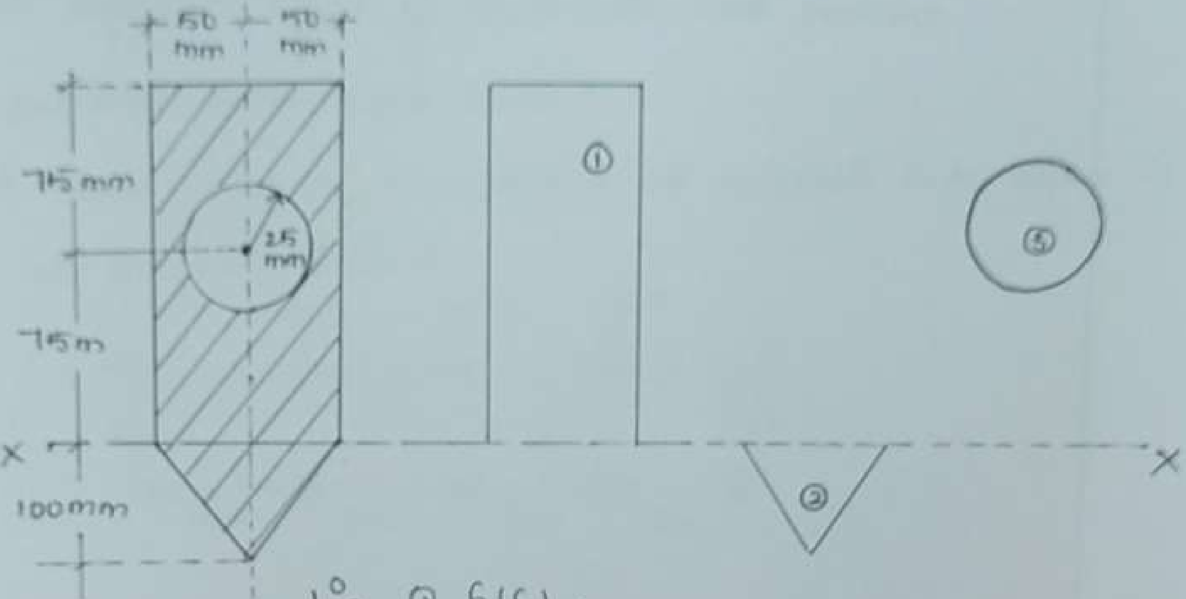


fig Q 6(c).

$$\longrightarrow \quad I_{xx} = I_{xx_1} + I_{xx_2} - I_{xx_3}$$

$$= \frac{bd^3}{12} + \frac{bh^3}{12} - \left[\frac{\pi R^4}{4} + a_3 h_3^2\right]$$

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

where $a_3 = \pi R^2 = \pi(25)^2 = 1963.50\,mm^2$.

$h_3 = 75mm$.

$$= 112.50\times10^6 + 8.33\times10^6 - 11.35\times10^6.$$

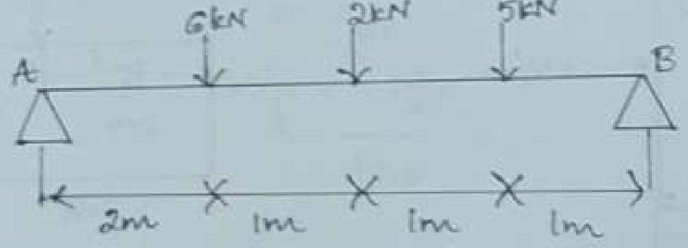
$$\underline{I_{xx} = 109.5\times10^6\ mm^4}.$$

MODULE - 04

7 a Explain different types of loads with neat sketches

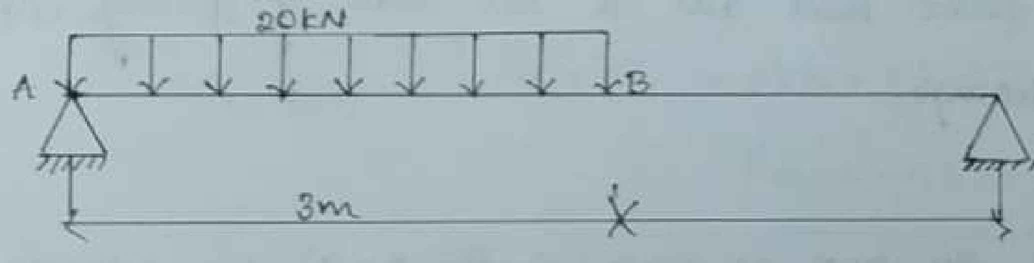
⇒ a) Concentrated load / Point loads :

A load which is concentrated at a point in a beam is known as concentrated loads.



b) Uniformly distributed load (UDL) :

A load which is distributed uniformly along the entire length of the beam is known as UDL such as the load 20kN per metre



To convert the 20kN/m UDL into a point load which is acting at the centre of a particular span (i.e 3m) we proceed as follows

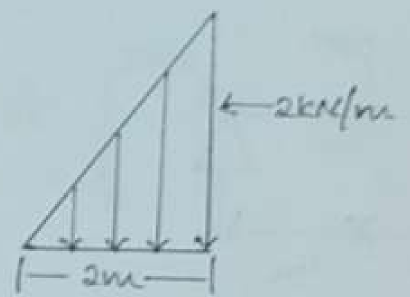
Magnitude of point load = 20 kN/m

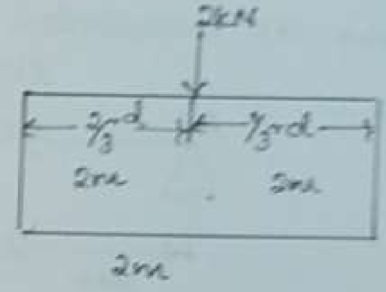
$= 20 \times 3$

$= 60 kN$

c) Uniformly varying load (UVL):

A load which varies with the length of the beam is known as uniformly varying load (UVL). The magnitude of the point load corresponding to a UVL such as that shown in fig. is calculated as follows.





Magnitude of point load = Ar. of Δ^{le}

$= \frac{1}{2} \times b \times h$

$= \frac{1}{2} \times 2 \times 2$

$= 2kN$

The point load acts at the centre of gravity (CG) of the triangle.

7 b) Analyse the truss as shown in fig Q.7(b) by methods of joints

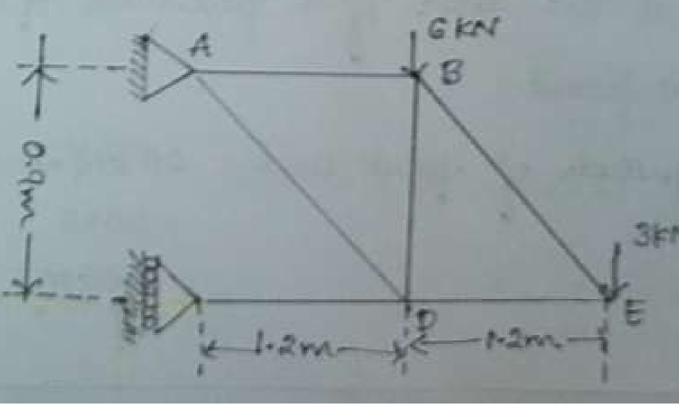


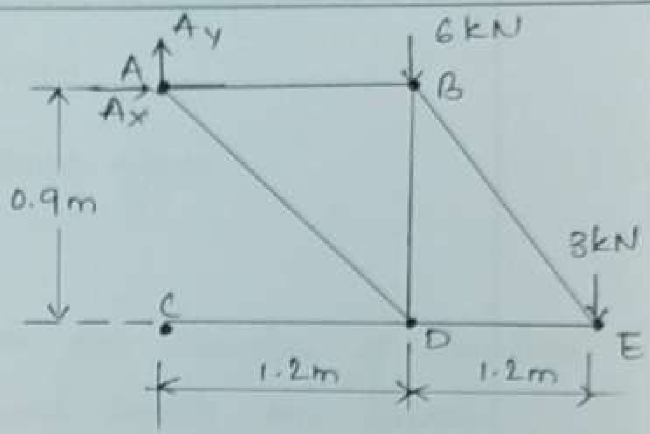
fig. Q.7(b)

Reactions:

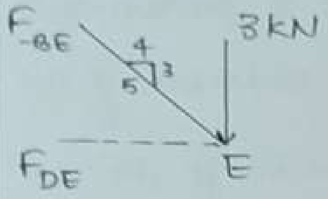
$\Sigma M_C = 0$: $A_x = 16\,kN \leftarrow$

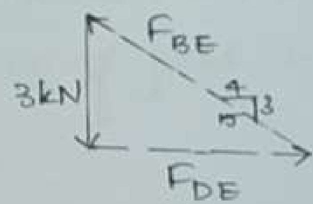
$\Sigma F_y = 0$: $A_y = 9\,kN \uparrow$

$\Sigma F_x = 0$: $C = 16\,kN \longrightarrow$



Joint E:



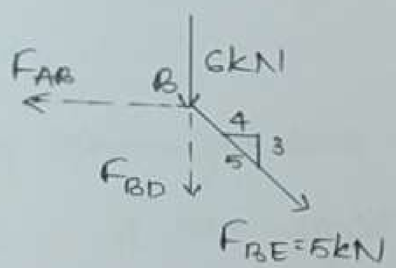


$$\frac{F_{BE}}{5} = \frac{F_{DE}}{4} = \frac{3\,kN}{3}$$

; $F_{BE} = 5\,kN\ (T) \leftarrow$

$F_{DE} = 4\,kN\ (C) \leftarrow$

Joint B:



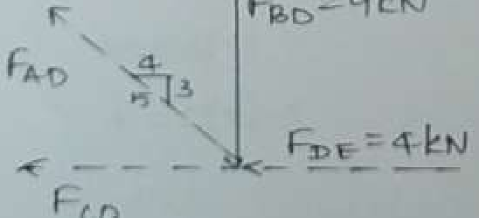
$\xrightarrow{+} \Sigma F_x = 0$: $\frac{4}{5}(5\,kN) - F_{AB} = 0$

$F_{AB} = 4\,kN\ (T) \leftarrow$

$+\uparrow \Sigma F_y = 0$: $-6\,kN - \frac{3}{5}(5\,kN) - F_{BD} = 0$

$F_{BD} = -9\,kN\ (C) \leftarrow$

Joint D:



$+\uparrow \Sigma F_y = 0$: $-9\,kN + \frac{3}{5} F_{AD} = 0$

$F_{AD} = 15\,kN\ (T) \leftarrow$

$\xrightarrow{+} \Sigma F_x = 0$: $-4\,kN - \frac{4}{5}(15\,kN) - F_{CD} = 0$

$F_{CD} = -16\,kN\ (C) \leftarrow$

8a. Write a note on classification of trusses.

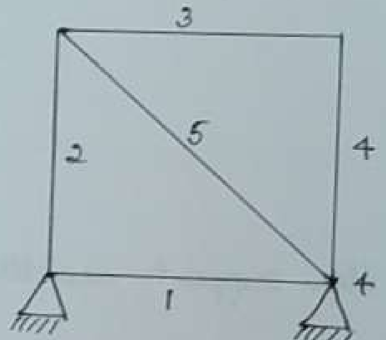
→ The trusses are classified into three types.

1) Rigid truss or perfect trusses:

A rigid truss is one in which the number of members are sufficient to resist the external loads in which deformation is very small. The relationship between the no. of members & no. of joint is given by $m = 2J - 3$ where

m = no. of members

n = no. of joints.



$m = 2J - 3$

$5 = 2 \times 4 - 3$

$5 = 5$

perfect truss

2) Non-rigid truss or deficient truss.

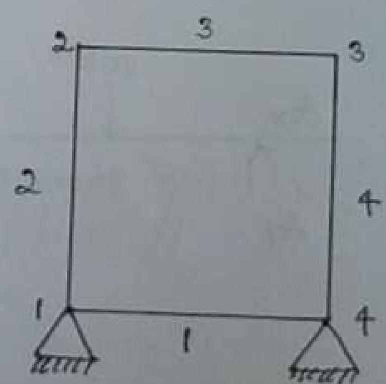
A non-rigid truss is one in which the no. of members are less than that required for a perfect truss.

The relationship between the no. of members & no. of joints is given by $m < 2J - 3$

$m < 2J - 3$

$4 < 2(4) - 3$

$4 < 5$



3) Over-rigid truss or redundant truss.

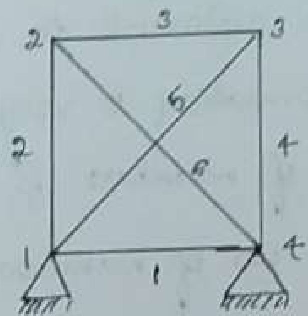
The over-rigid truss is one in which the no. of members are more than that required for a perfect truss.

The relationship between the no. of members and no. of joint is given by $m > 2J-3$.

$m > 2J-3$

$6 > 2(4)-3$

$6 > 5$



8 b. Find the support reactions for the beam as shown in fig Q8(b).

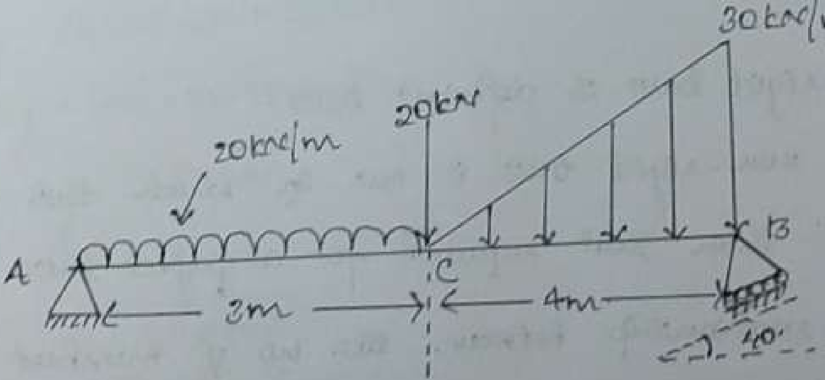
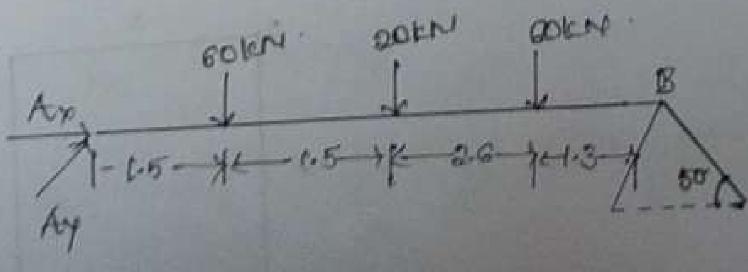


Fig. Q8(b).

⇒



C. A roof truss is loaded as shown in fig Q8 (c). Determine the forces in members BC, GF and CG.

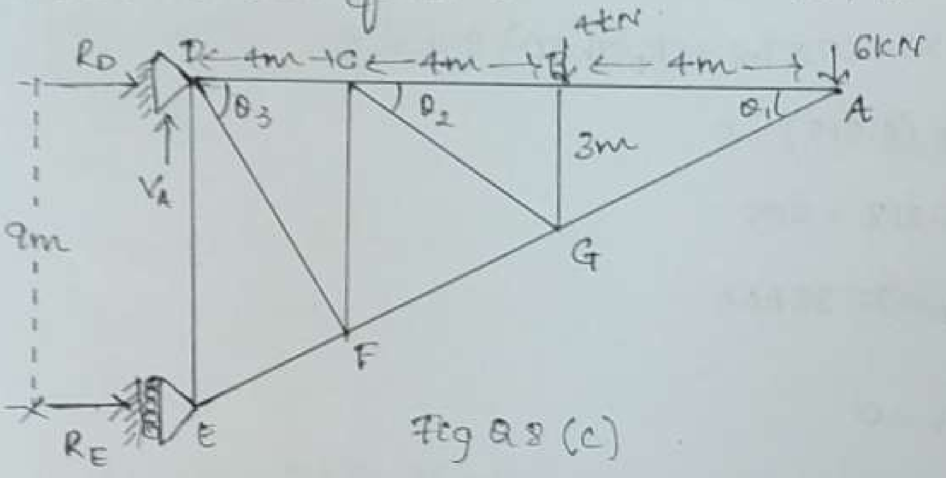


Fig Q8 (c)

$\Sigma F_x = 0.$

$R_D + R_E = 0$ —— (1).

$\Sigma F_y = 0.$

$\therefore V_A = 4+6 = 10kN.$

$M_A = 0.$

$-4\times 8 - 6\times 12 + R_E \times 9 = 0.$

$R_E = 11.55 kN.$

From (1), $R_D = -11.55kN.$

$\theta_1 = \tan^{-1}\left(\frac{9}{12}\right) = 36.86°.$

$\theta_2 = \tan^{-1}\left(\frac{4\tan(36.86)}{3}\right)$

$\theta_2 = 44.98°.$

$\theta_3 = \tan^{-1}\left(\frac{8\tan(36.86)}{3}\right)$

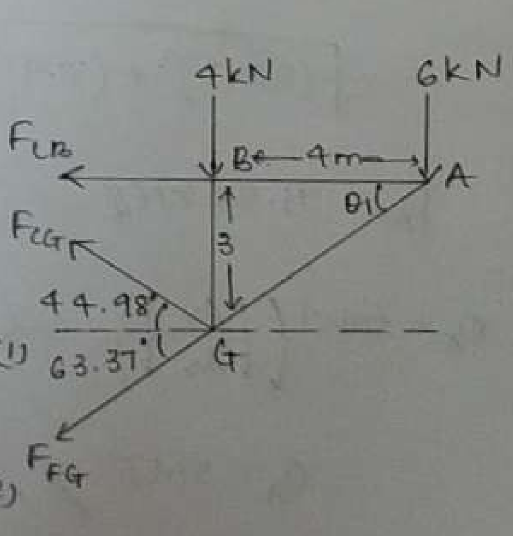
$\theta_3 = 63.37°.$

By method of selection:

$M_G = 0$

$F_{CB} \times 3 - 6\times 4 = 0$

$F_{CB} = 8kN.$



$\Sigma F_x = 0$

$F_{CG}\cos 44.98 + F_{FG}\cos 36.86 = -8$ —— (1)

$\Sigma F_y = 0$

$F_{CG}\sin 44.98 + F_{FG}\sin 36.86 = 10$ —— (2)

Taking
$\Sigma M_A = 0$

$-60\times1.5 - 20\times3 - 60\times7.6 + (R_B\sin50)\,8.9 = 0$

$-606 + R_B(6.818) = 0$

$R_B\,6.818 = 606$

$R_B = 88.88\,kN$

Taking $\Sigma F_x = 0$

$A_x + R_B\cos50 = 0$

$A_x = 88.88\cos50$

$A_x = 57.13\,kN$

Taking $\Sigma F_y = 0$

$A_y - 60 - 20 - 60 + R_B\sin50 = 0$

$A_y = 140 - 88.88\sin50$

$A_y = 71.91\,kN$ //

$R_A = \sqrt{A_x^2 + A_y^2}$

$= \sqrt{(57.13)^2 + (71.91)^2}$

$R_A = 91.84\,kN$ //

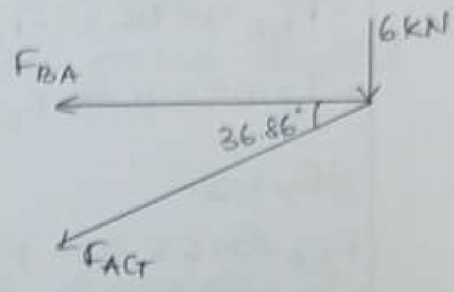
$\theta_A = \tan^{-1}\left(\left|\frac{A_y}{A_x}\right|\right) \Rightarrow \tan^{-1}\left(\left|\frac{71.91}{57.13}\right|\right)$

$\theta_A = 51.53^\circ$ /

From (1) and (2), $\underline{F_{CG} = 90.6\,kN}$; $\underline{F_{FG} = -90.1\,kN}$

By method of joint,

<u>Joint A</u>



$\Sigma F_y = 0$

$-F_{AG} \sin 36.86 - 6 = 0$

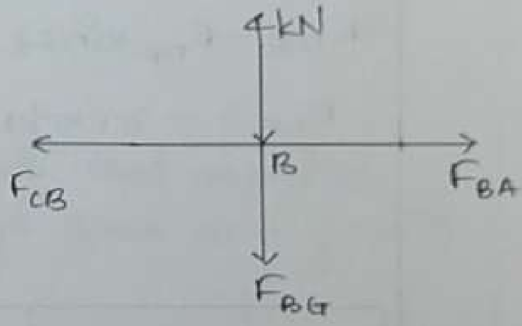
$\underline{F_{AG} = -10\,kN}$.

$\Sigma F_x = 0$

$-F_{BA} - F_{AG} \cos 36.86 = 0$.

$\therefore \underline{F_{BA} = 8\,kN}$.

<u>Joint B</u>



$\Sigma F_y = 0$

$-4 - F_{BG} = 0$

$\therefore \underline{F_{BG} = -4\,kN}$.

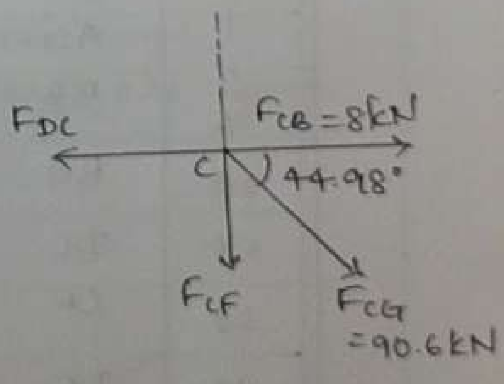
<u>Joint C</u>:

$\Sigma F_x = 0$

$-F_{DC} + F_{CB} + F_{CG} \cos 44.98 = 0$

$F_{DC} = 8 + 90.6 \cos 44.98$

$\underline{F_{DC} = 72.09\,kN}$.

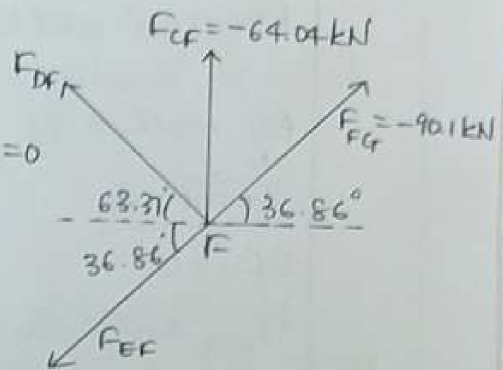


$\Sigma F_y = 0$

$-F_{CF} - F_{CG} \sin 44.98 = 0$

$\underline{F_{CF} = -64.04\,kN}$.

Joint F :



$\Sigma F_x = 0$

$-F_{DF}\cos 63.37 - F_{EF}\cos 36.86 - 90.1\cos 36.86 = 0$

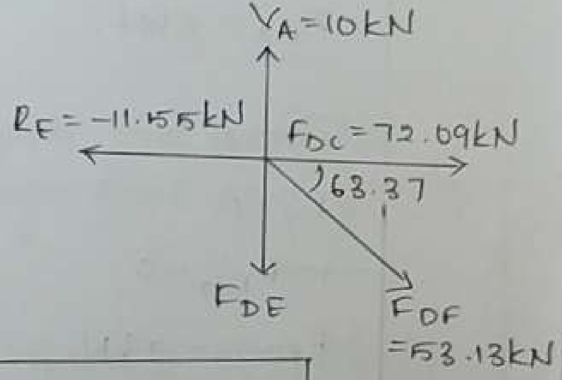
$-72.09 = 0.45\,F_{DF} + 0.8\,F_{EF}$ —— (1)

$\Sigma F_y = 0$

$F_{DF}\sin 63.37 - F_{EF}\sin 36.86 - 64.04 - 90.1\sin 36.86 = 0$

$0.89\,F_{DF} - 0.59\,F_{EF} = 118.09$ —— (2)

$\Rightarrow$ $\underline{F_{DF} = 53.13\,kN}$ and $\underline{F_{EF} = -120\,kN}$.



$\Sigma F_y = 0$

$-F_{DE} - F_{DF}\sin 63.37 + 10 = 0$

$\therefore$ $\underline{F_{DE} = -37.5\,kN}$.

SI. No	Member	Force
1	CB	8kN (T)
2.	CG	90.6kN (T)
3.	FG	90.1kN (C)
4.	AG	10kN (C)
5.	BA	8kN (T)
06.	BG	4kN (C)
07.	DC	72.09 kN (T)
08.	CF	64.04kN (C)
09.	DF	53.13kN (T)
10.	EF	120kN (C)
11	DE	37.5kN (C)

MODULE -05

07. a. Define

i) Time of flight.

=> The total time a particle remainded in space from the instant of its projection till it reaches the ground is called time of flight.

ii) Horizontal range.

=> The horizontal distance from the point of projection of a particle till it reaches the ground is called horizontal range.

iii) Maximum Height.

=> Maximum height of the object is the heighest vertical position along its trajectory.

iv) Trajectory.

=> A trajectory or flight path is the path that an object with mass in motion follows through space as a function of time.

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.

=>

i) $R = 4h$

ii) $h = 4R$

iii) $h = R$

$$R = \frac{u^2 \sin 2\alpha}{g} \quad - ①$$

$$h_{max} = \frac{u^2 \sin^2\alpha}{2g} \quad - ②$$

$$\frac{u^2 \sin^2\alpha}{2g} = \frac{u^2 \sin 2\alpha}{g}$$

$$2 = \frac{\sin^2\alpha}{\sin 2\alpha} \Rightarrow \alpha = 70.48$$

$R = 4h$

$R = 4(162.1)$

$R = 648.4$

$$h = \frac{u^2 \sin^2\alpha}{2g}$$

$$h = \frac{(60)^2 \sin^2(70.48)}{2(9.81)}$$

$$h = 162.1\,m$$

Time of flight, $T = \frac{2u\sin\alpha}{g}$

$$T = \frac{2(60)\sin(70.48)}{8}$$

$$\boxed{T = 14.14\,s}$$

10. a. State and explain D' Alembert's principle.

⇒ Newton's second law of motion states that, the rate of change of momentum is directly proportional to the impressed force and takes place in the same direction in which the forces acts.

This statement leads to the equation $F = ma$

where, F = Force

m = mass, a = acceleration due to gravity.

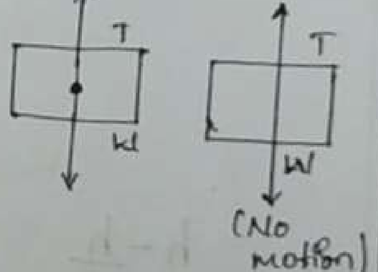
A number of forces acting on a body can be converted into a single resultant force. Then Newton's second law gets modified as

$R = ma$

Case i) <u>Lift at rest</u> $(a=0)$

$\Sigma V = 0$, $T = W$

Hence tension in string (T) will be equal to weight of object (W)



Case ii) <u>Lift moving with constant velocity</u> $(a=0)$

$T = W$

Case iii) <u>Lift acceleration upwards</u>

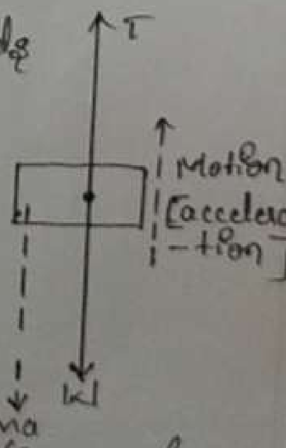
Let 'a' be the acceleration of lift upwards

(Inertia force ma opposes motion i.e, downwards)

$\Sigma V = 0$, $T - W - ma = 0$

$T = W + ma$

$= W\left(1 + \frac{a}{g}\right) \left(\because m = \frac{W}{g}\right)$

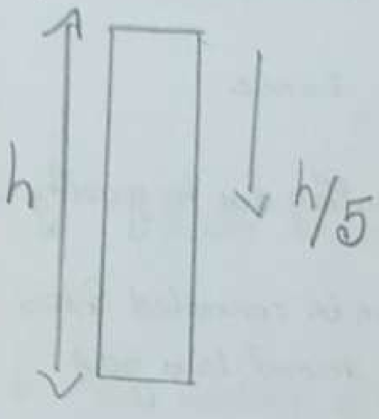


Hence, apparent weight is more

i.e while moving upwards the object exerts more force.

c. A stone is released from top of a tower 'h' meter in height. It covers a vertical distance of 'h/5' meter during the last second of descend. Find the height of the tower.

$\Rightarrow$

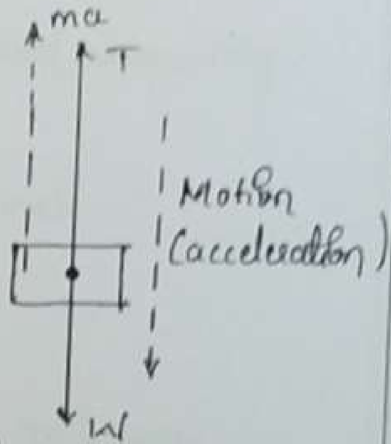


Given :) Height of the tower is h

$$h - \frac{h}{5}$$

$$\frac{5h-h}{5} \Rightarrow \frac{4h}{5}$$

Case iv) <u>Lift acceleration downwards</u>
(inertia force opposes motion)



$$T - W + ma = 0$$

$\Sigma V = 0, \quad T = W - ma$

$$= W\left(1 - \frac{a}{g}\right)$$

While moving downwards the man exerts less force.

b. The motion of a particle is defined by $x = (t+1)^2$ & $y = 4(t+1)^{-2}$ where x & y are in meters and t in seconds. Show that path of particle is part of rectangular hyperbola. Find the velocity and acceleration at $t = 0$

$\Rightarrow$ To find the path travelled, we know that

$$x = (t+1)^2$$
$$y = 4(t+1)^{-2}$$

Multiplying the two equations

$$xy = 4 \quad [\because xy = \text{constant}]$$

This represents a rectangular hyperbola

W.K. $x = (t+1)^2$

component of velocity in x direction $V_x = 2(t+1)$

component of acceleration in x direction $a_x = \frac{d^2x}{dt^2} = 2 \, m/s^2$

When $t = 0$ $\quad V_x = 2 m/s^2$

$\qquad\qquad a_x = 2 m/s^2$

W.K. $y = 4(t+1)^{-2} = \frac{4}{(t+1)^2}$

component in velocity in y direction

$$V_y = \frac{dy}{dt} = 4(-2)(t+1)^{-3}$$

$$= -8(t+1)^{-3}$$

Component of acceleration in y direction

$$a_y = \frac{d^2y}{dt^2} = (-8)(-3)(t+1)^{-4}$$

$$= -24(t+1)^{-4}$$

when $t = 0$, $V_y = -8(0+1)^{-3} = -8\ m/s$

$$a_y = -24(0+1)^{-4} = +10\ m/s$$

$$\text{Velocity} = V = \sqrt{V_x^2 + V_y^2}$$

$$\sqrt{2^2 + (-8^2)}$$

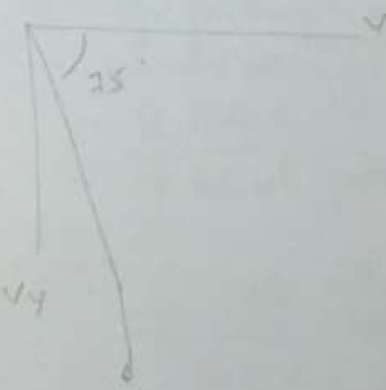
$$\tan\theta = \frac{V_y}{V_x} = \frac{-8}{2}$$

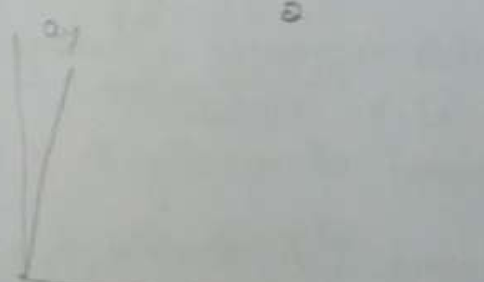
$$\tan\theta = -4 = 75.96$$

$$\text{Acceleration} = a = \sqrt{a_x^2 + a_y^2}$$

$$= \sqrt{2^2 + (24)^2} = 24.08$$

$$\alpha = \tan^{-1}\frac{24}{2} = 85.23$$





c. Two cars moving in the direction are 150 m part. Car A being ahead of car B, at this instant velocity of car A is 3m/s and constant acceleration of 1.2 m/s². While the velocity of car B is 30m/s and its uniform retardation is 0.6 m/s². How many times do the

Cars cross each other ? Find when and where they cross w.r.t given position of car A.

→

The velocity of car A $= V_A = 3 m/s$

The velocity of car B $= V_B = 30 m/s$

The acceleration of car A $= a_A = 1.2 m/s^2$

The acceleration of car B $= a_B = -0.6 m/s^2$

For car A:-

$\boxed{a = \frac{v}{t}} \Rightarrow \boxed{t = \frac{v}{a}}$

$t_1 = 2.5 sec$

$s = vt$

$s = 3 \times 2.5$

$s_1 = 7.5 m$

For car B:-

$t = \frac{v}{a} \Rightarrow \frac{30}{-0.6} \Rightarrow t_2 \Rightarrow -50 sec$

$s = vt$

$s_2 = -1500 m$

$\frac{t_2}{t_1} \Rightarrow 20$

$\frac{s_2}{s_1} = 200$