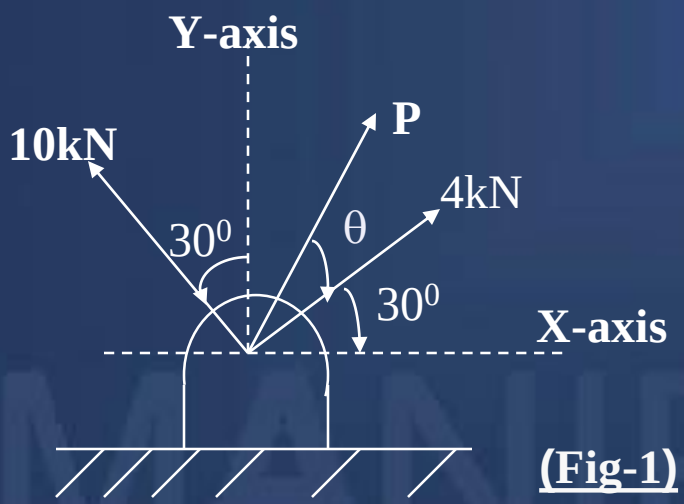
Exercise Problems
coplanar concurrent and non concurrent force system
Resultant and Equilibrium Problems

1). Determine the angle θ and the magnitude of the force P such that the resultant of the three forces is vertically upwards and of magnitude 12 kN. (Fig-1) ANS: P=2.04kN, θ = 11.03^0

2). Determine the angle α and the magnitude of the force Q such that the resultant of the three forces on the pole is vertically downwards and of magnitude 12 kN. (Fig-2) ANS:α = 10.7 º,Q = 9.479 kN



(Fig-1)

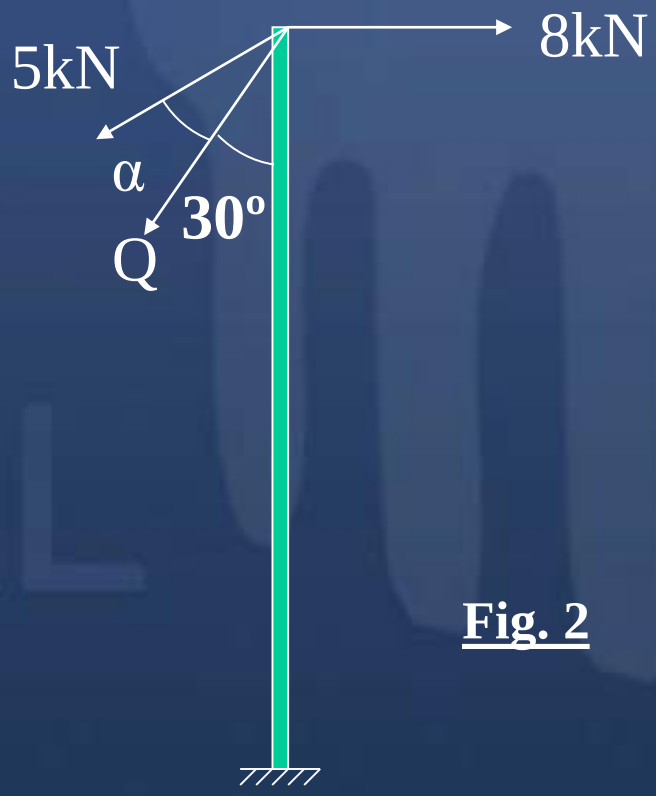


Fig. 2

3. Find the resultant of the force system shown on a regular hexagon with respect to point E. (Fig–3). [ANS: R = 13.42 kN, ΣM_E = -15.46kN-m, d = 1.15m]

4. Find the resultant of the force systems and moment acting on the body shown in Fig- 4. Also determine equivalent system at A. [ANS:R = 383.13, $\Theta_x = 31.46^0$, ΣM_A = 2500 N-m, d = 6.52m,

Fig–3

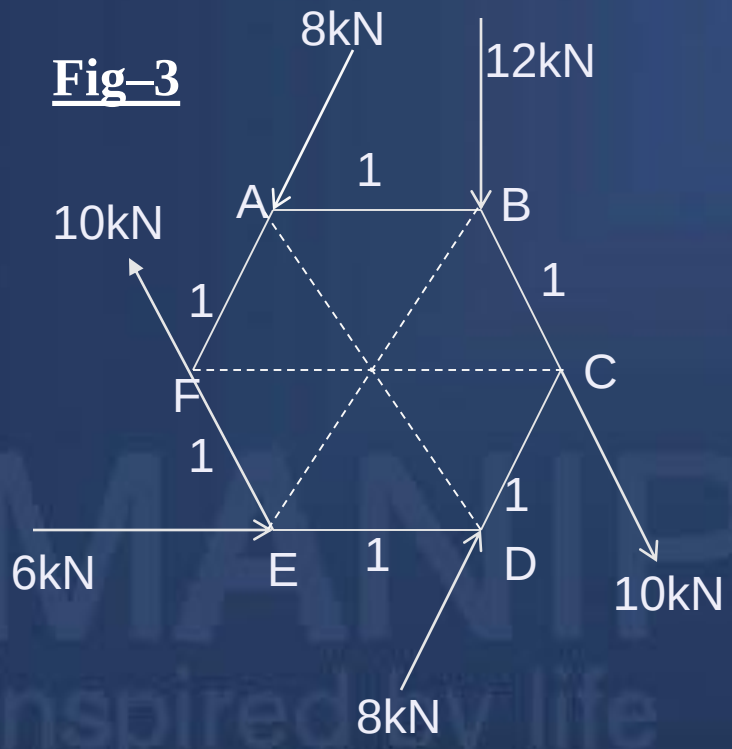
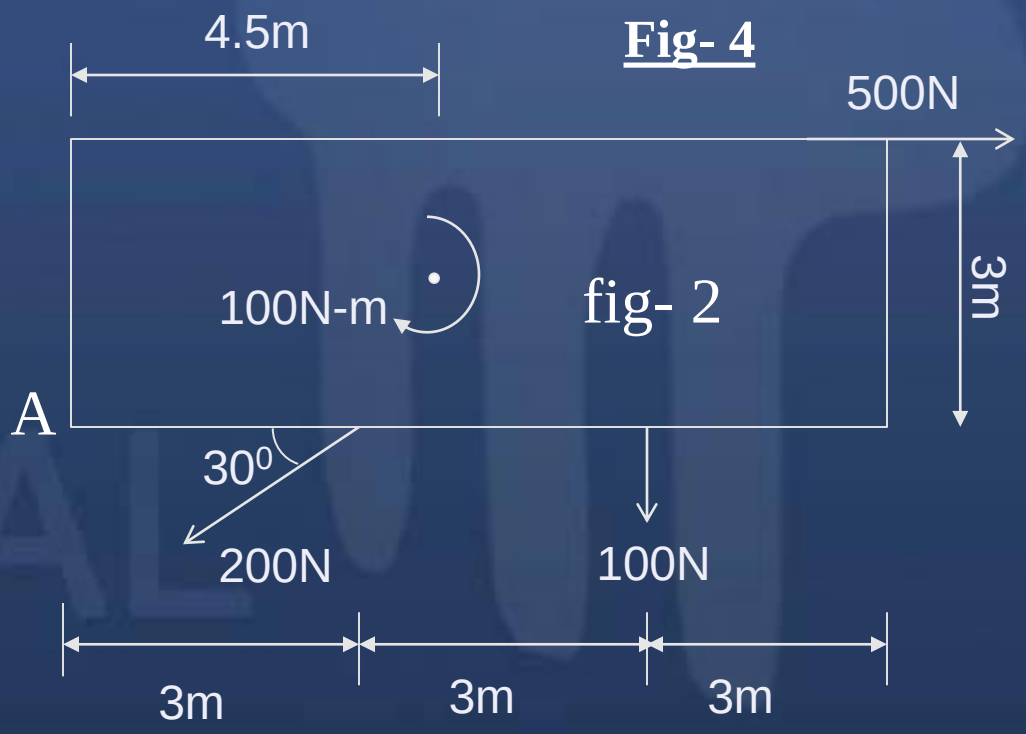


Fig- 4



5) Locate the resultant w. r. to point as shown in Fig-5

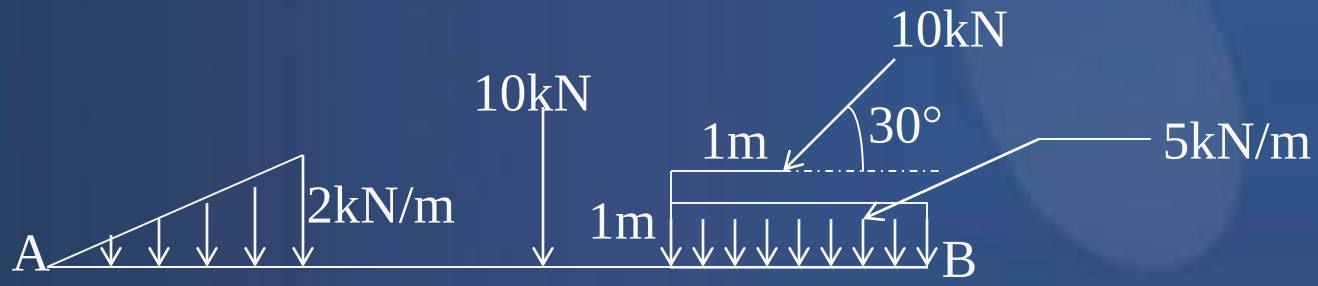


Fig-5

ANS: R = 28.35kN,
d = 4.38m

6) Determine the unknown values, given the value of the resultant as R = 375N as shown in Fig-6.

Ans: F_A =4550N,
$\theta = 89.69^0$, F_C = 4050N

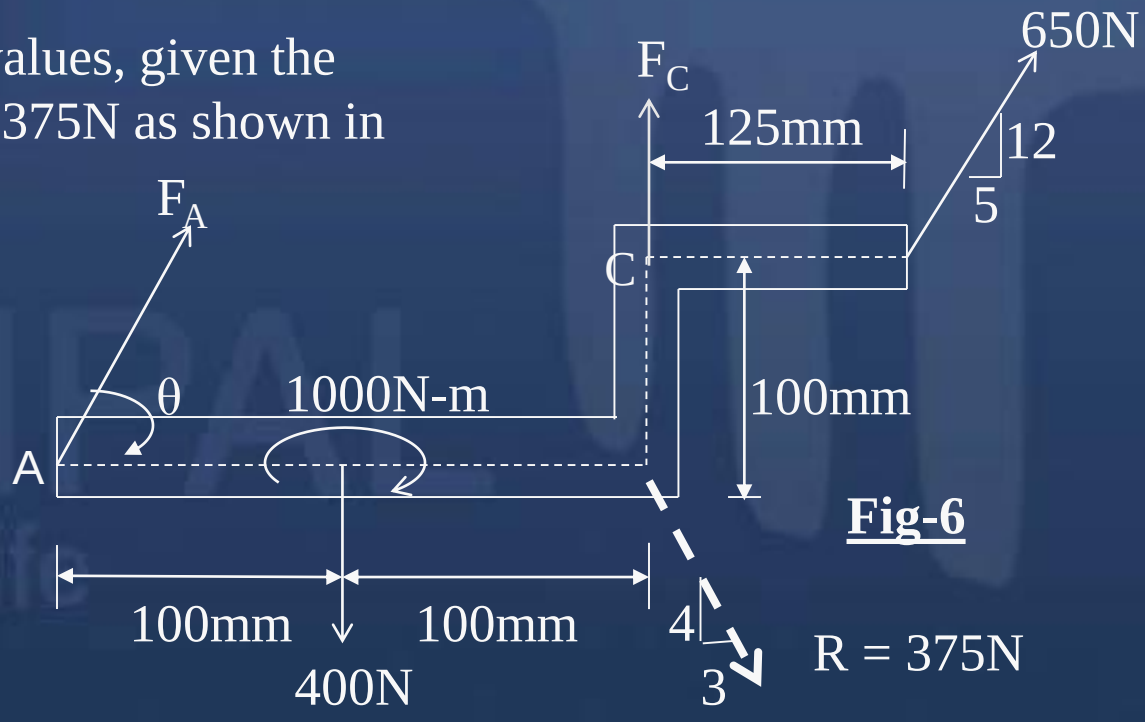


Fig-6

7) Determine the resultant with respect to point A as shown in Fig -7.

Ans: R = 338.59N, d = 5.32m

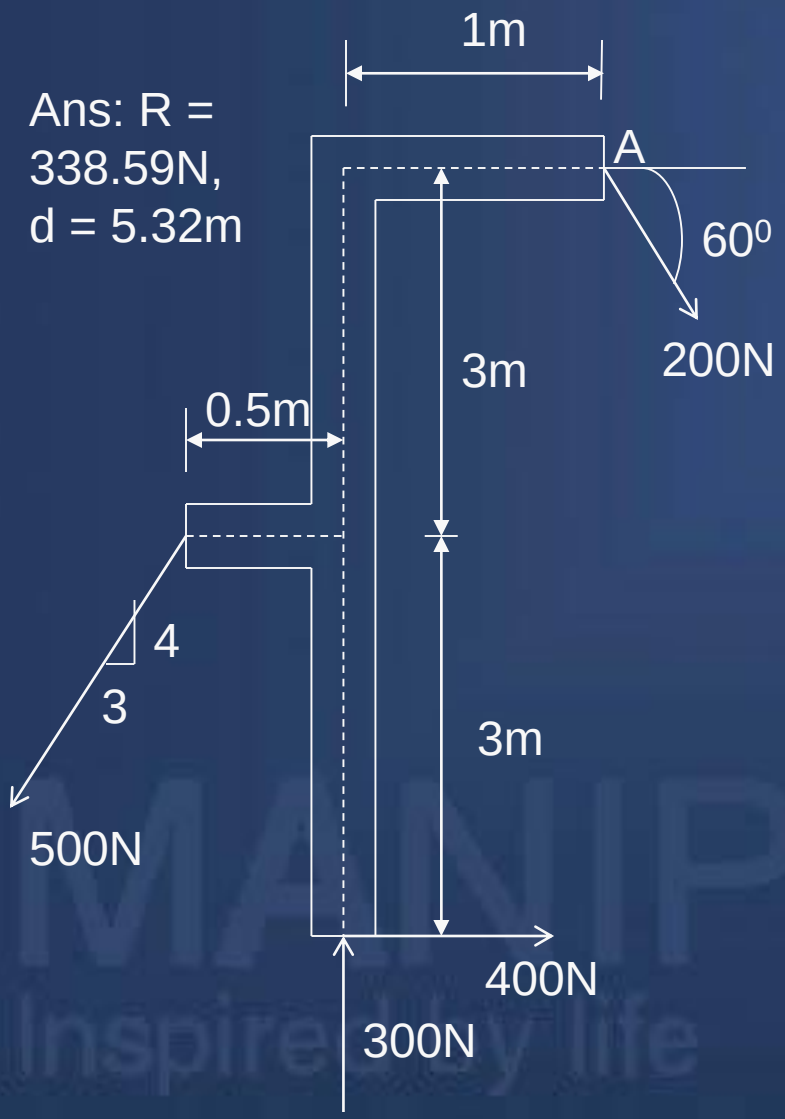


Fig -7

8) A 300N box is held at rest on a smooth plane by a force P inclined at 45^0 with the plane as shown in Fig -8 Determine the value of P and the normal reaction exerted by the plane. Ans: P =212.13N, RN = 409.81N

If value of P = 180N, determine the angle at which it must be inclined with the smooth plane to hold 300N box in equilibrium. Ans: $\theta = 33.56^0$

9) A wire is fixed at two points A and D as shown in Fig -9. Determine inclination of the segment BC to the vertical and the tension in all the segments.(ANS: T_{BA}=38.98kN,T_{CD}=22.51kN θ=54.79^0 T_{BC}= 23.86kN)

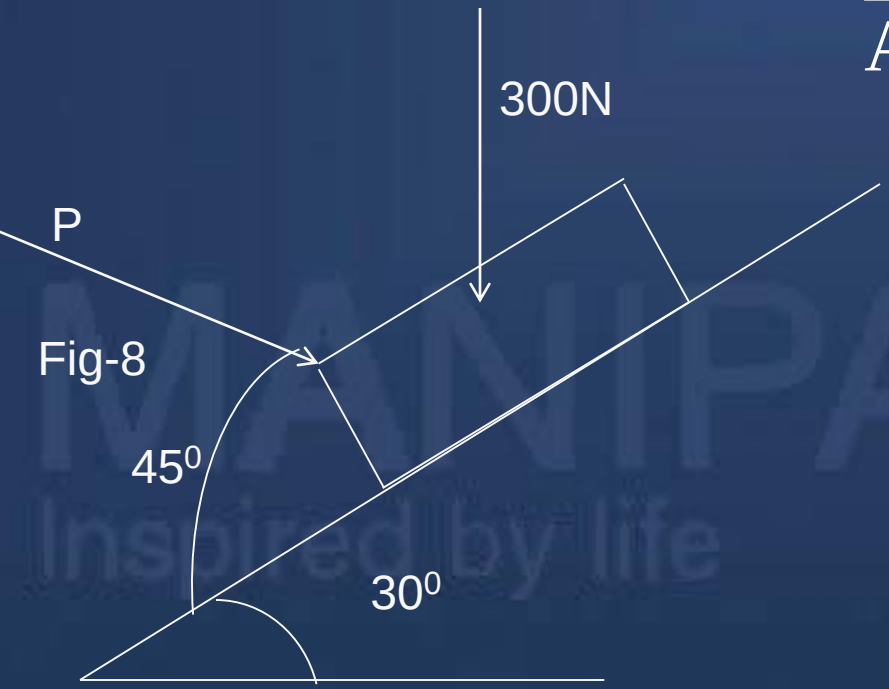


Fig-8

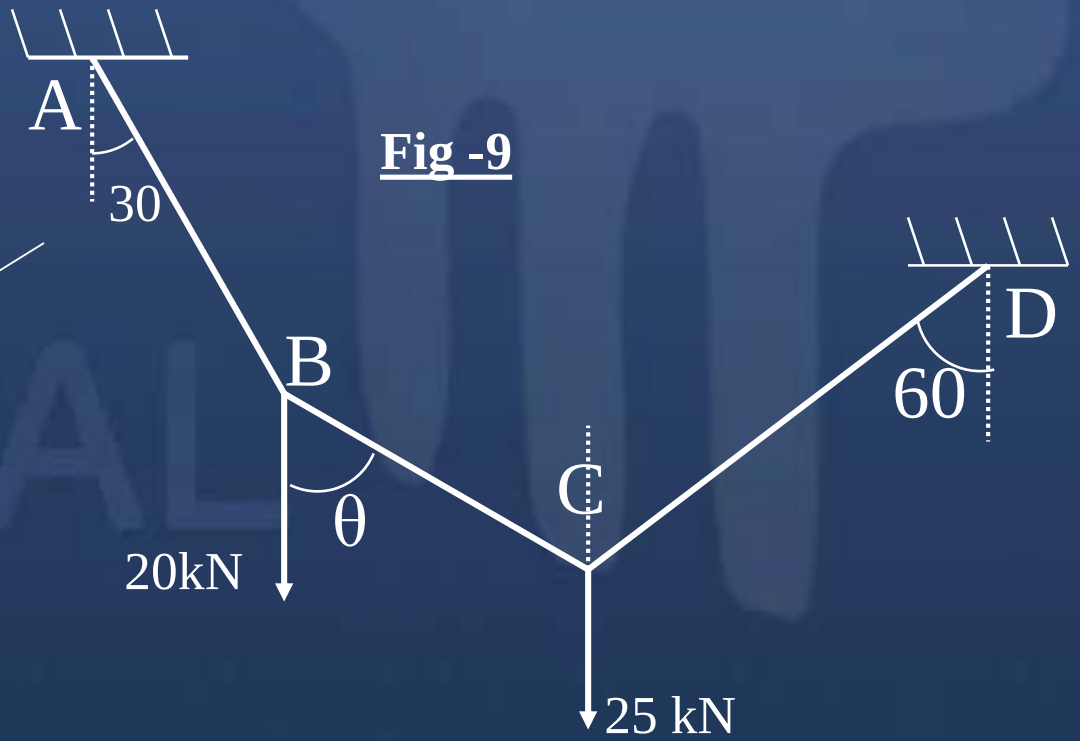
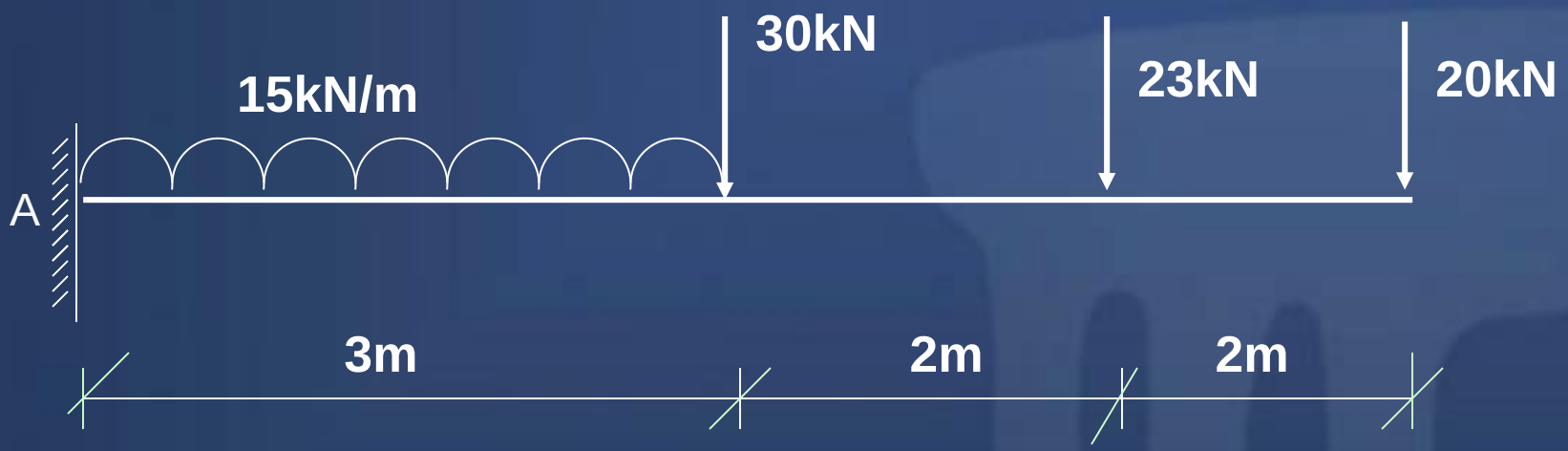


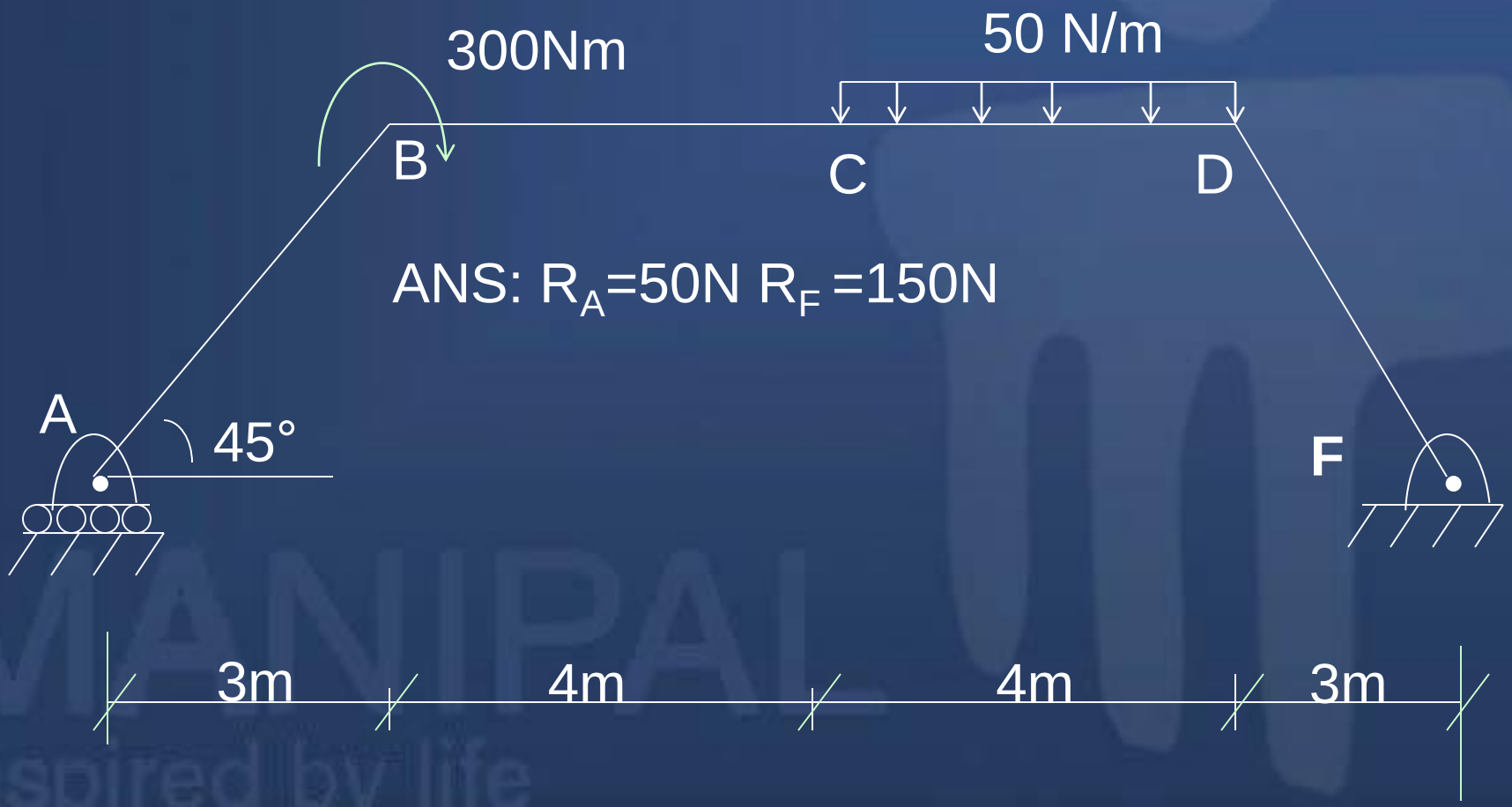
Fig -9

10. Find the Support reactions for the beam loaded as shown in the figure.



[Ans: R_A = 118kN M_A =412.5kNm]

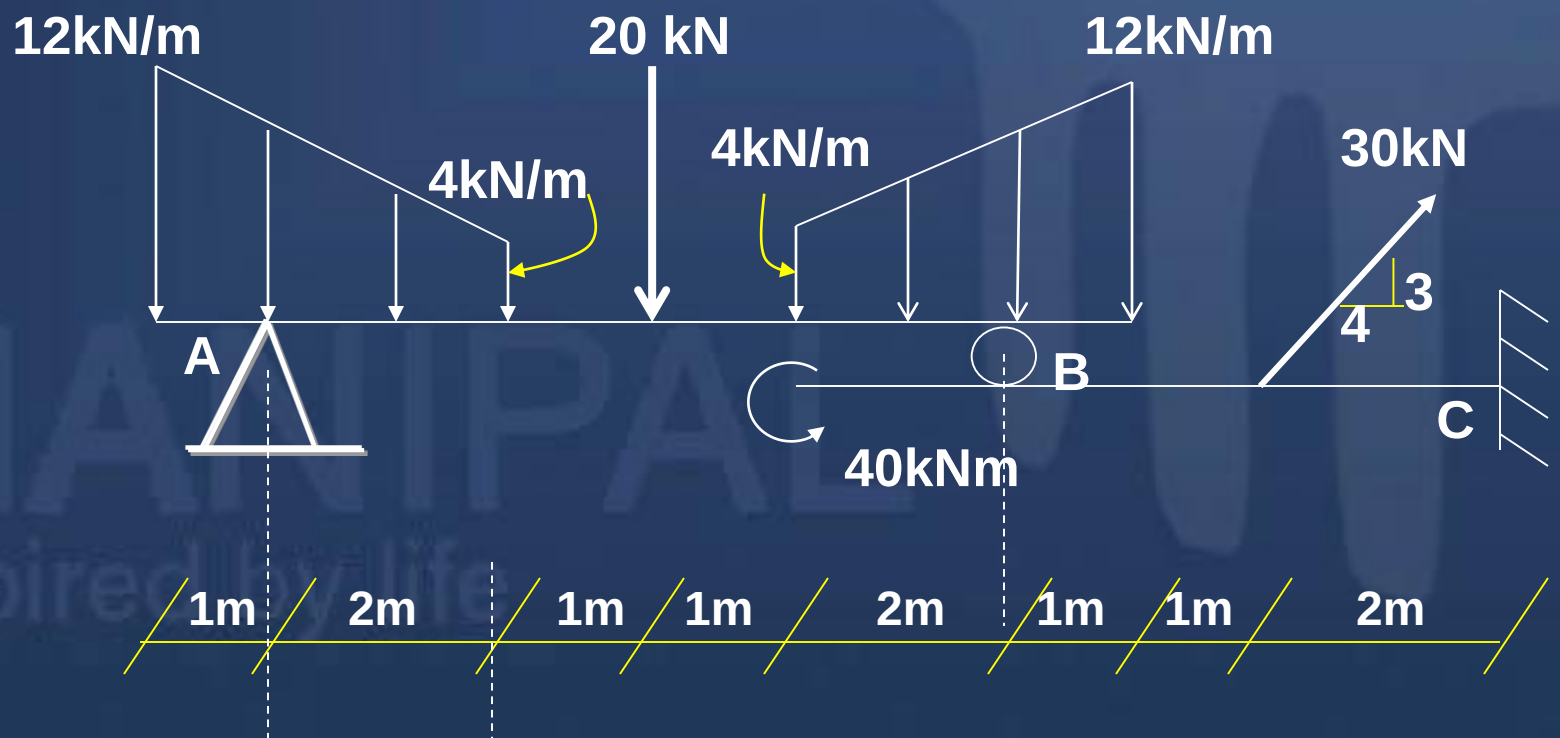
11. Compute the reactions for the bent beam shown in the figure at A and F.



ANS: R_A=50N R_F =150N

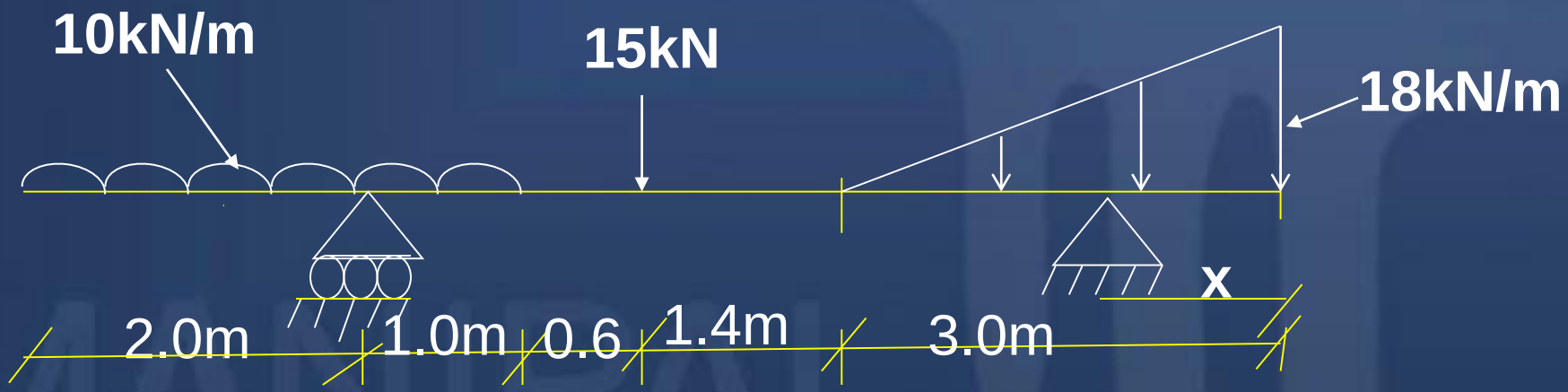
12. Find the reactions at A,B,C and D for the beam loaded as shown in the figure. (Ans.R_A=R_B =34kN;R_C=28.84kN;

M_C=-140kNm ; θ_C=-33.69 ˚)

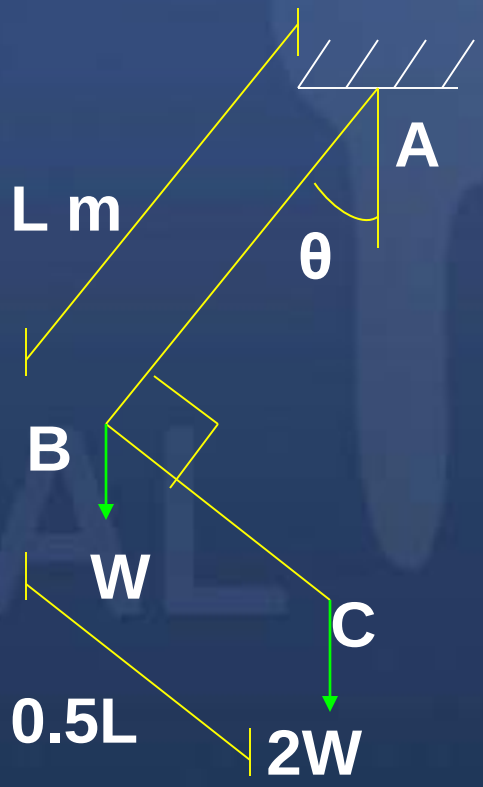


13. Find the position of the hinged support (x),such that the reactions developed at the supports of the beam are equal..

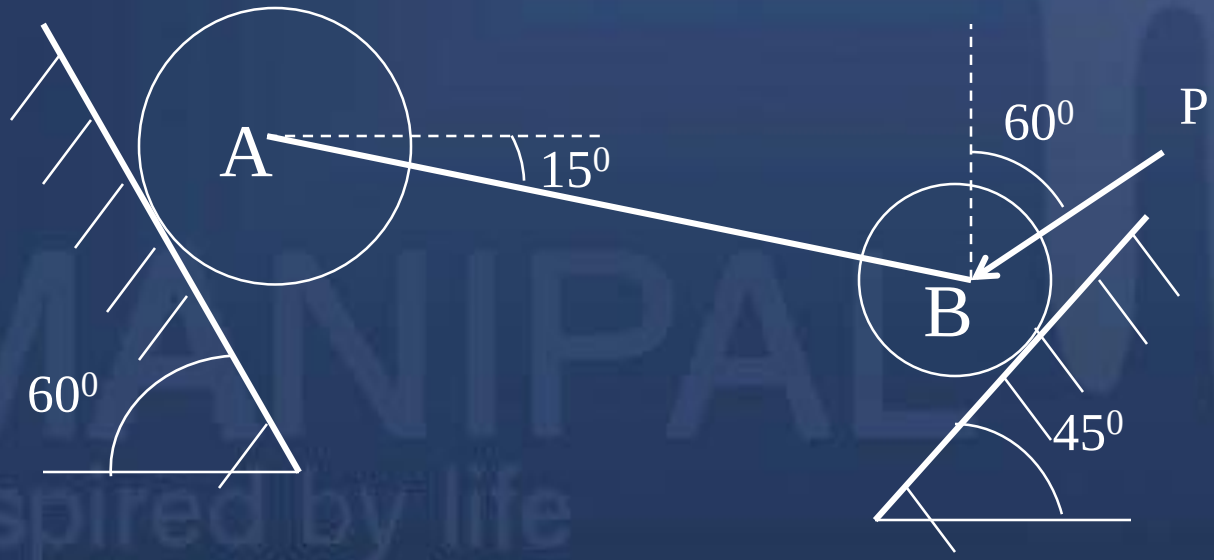
(Ans.x=2m**.)**



14. A right angled bar ABC hinged at A as shown in fig carries two loads W and 2W applied at B &C .Neglecting self weight of the bar find the angle made by AB with vertical (Ans:θ =18.44˚)

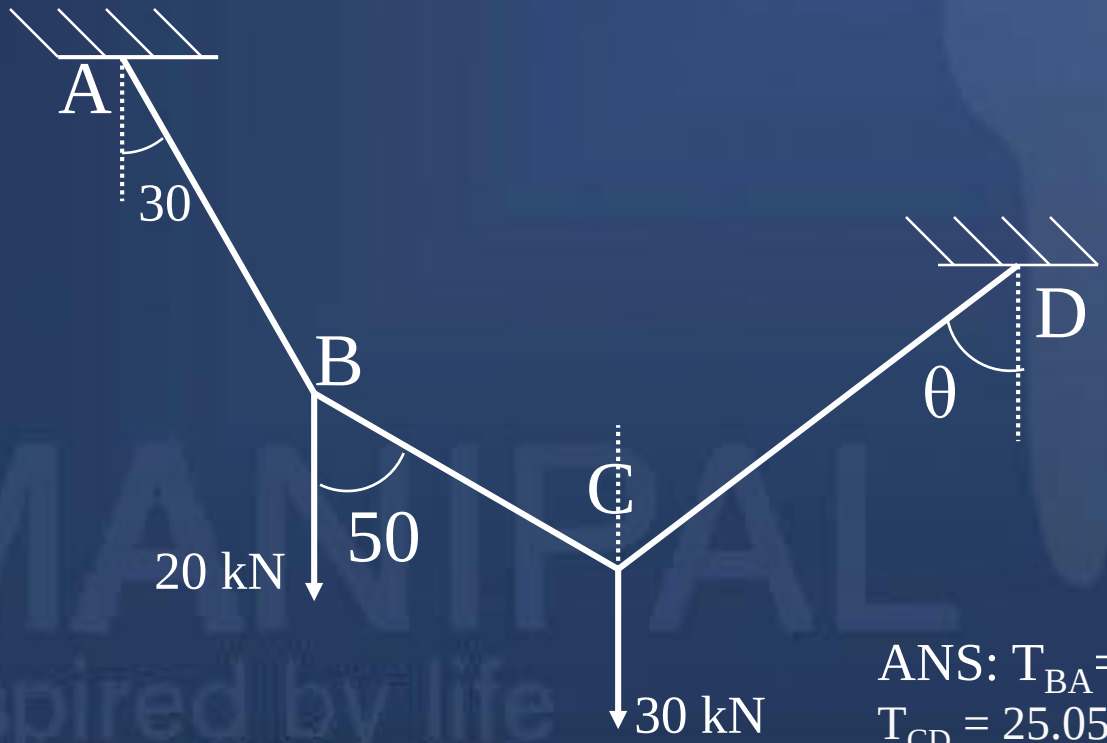


(15) Two cylinders A & B of weight 400N and 200N respectively, rest on smooth planes as shown in Fig. Find the force ‘P’ required for equilibrium.



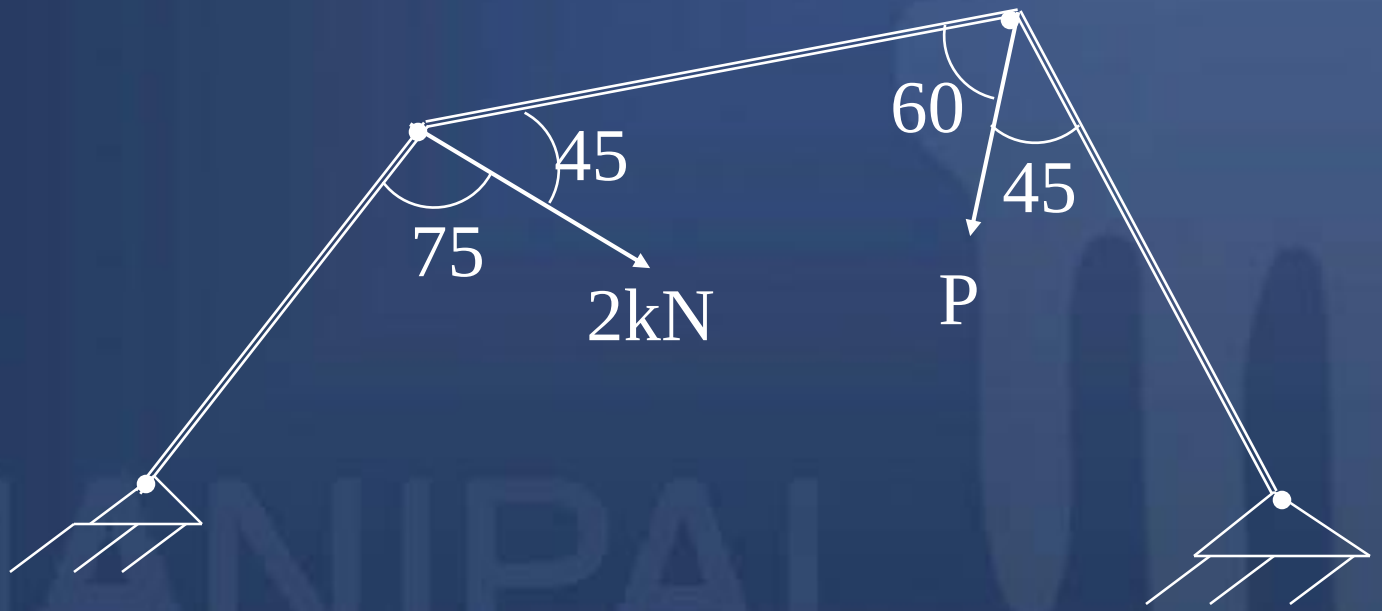
ANS: P = 1071.8N

(16) Determine, the tension in the strings AB, BC, CD and inclination of the segment CD to the vertical, in the system shown in Fig

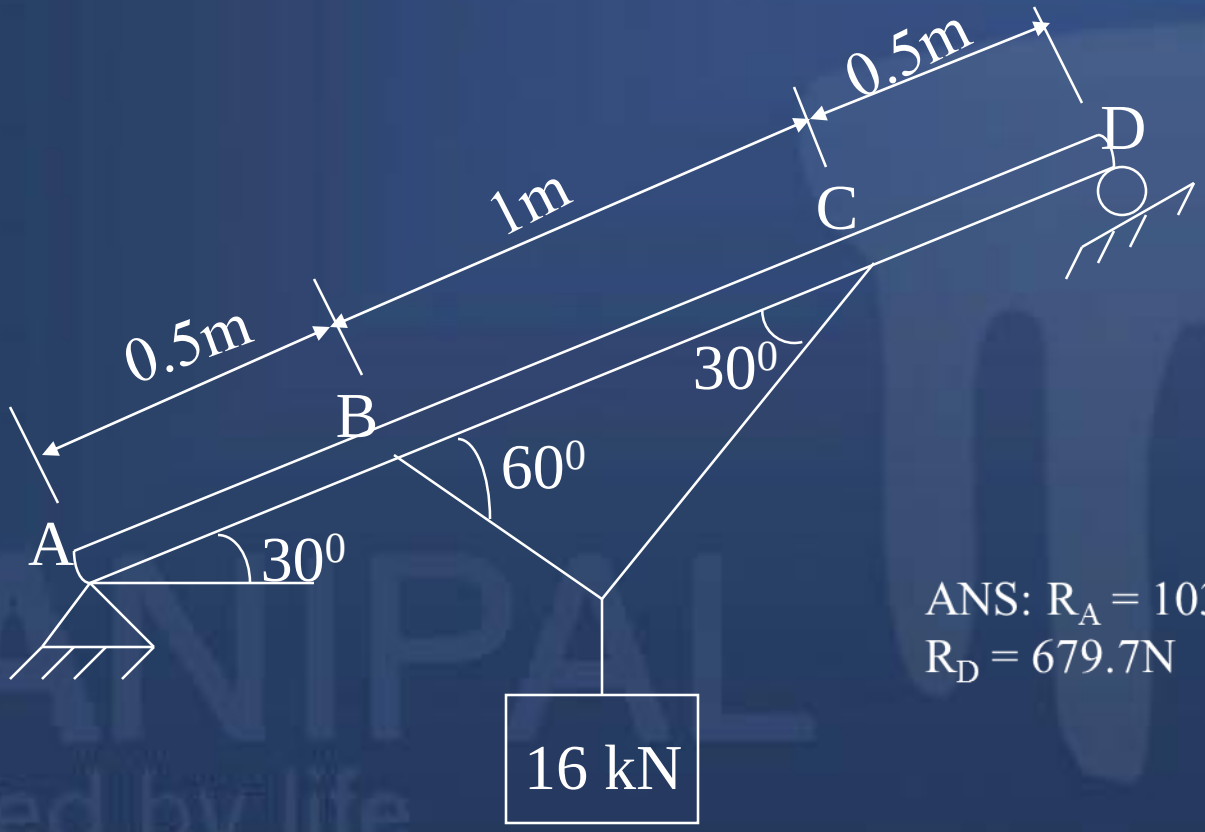


ANS: T_{BA}=44.8kN, T_{BC}=29.24kN, T_{CD} = 25.05kN, $\theta = 63.42^0$

17] Determine the value of P and the nature of the forces in the bars for equilibrium of the system shown in Fig.
[Ans: P = 3.04 kN, Forces in bars are Compressive.]



18) A bar 2m long is given hinged support at point A and roller support at D as shown in Fig. Determine the support reaction at A and D.

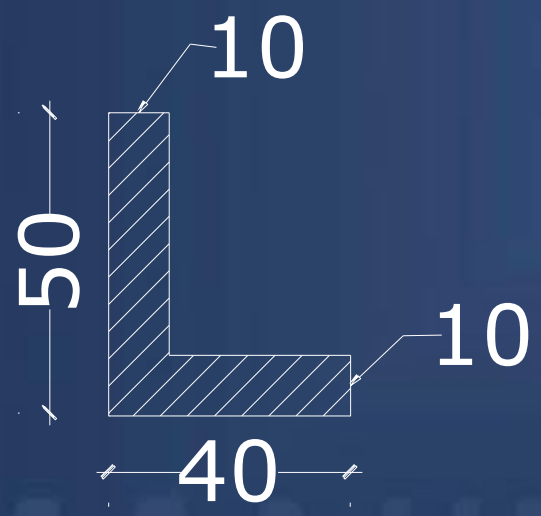


ANS: $R_A = 1038.2N, \theta_X = 40.90$
$R_D = 679.7N$

EXERCISE PROBLEMS

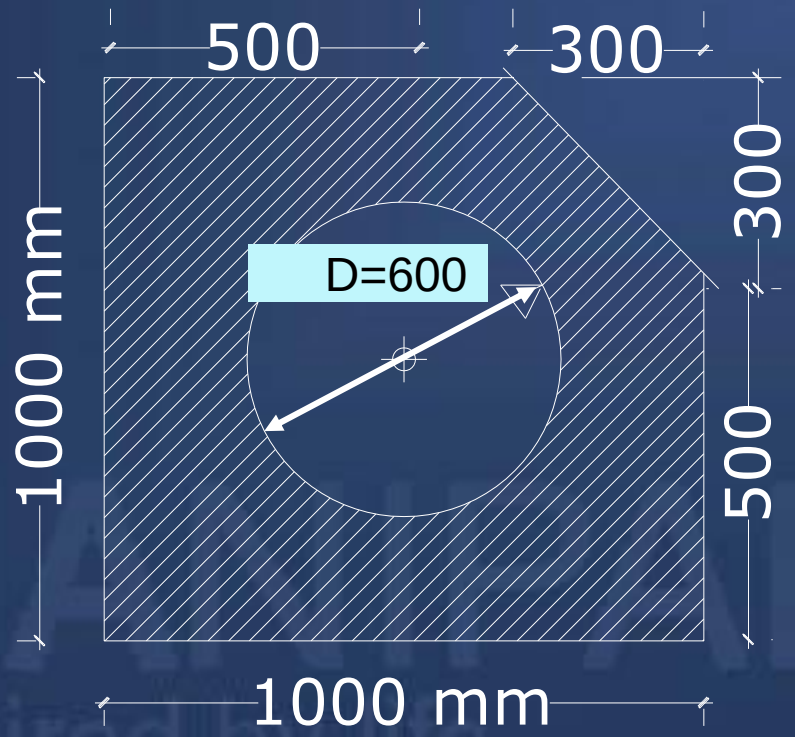
Centroid and Moment of Inertia

1) Locate the centroid of the shaded area shown



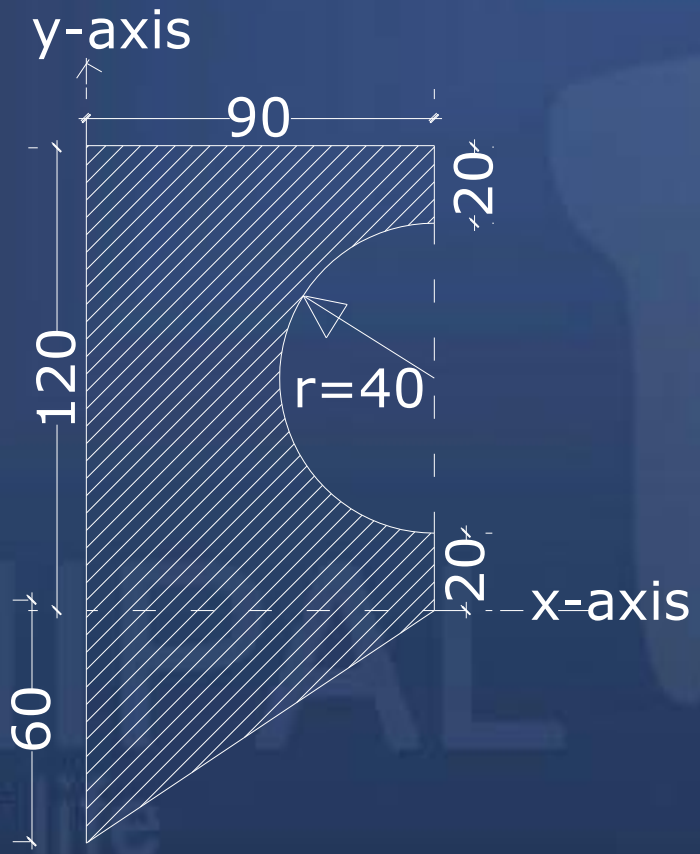
Ans: $\bar{x}$=12.5, $\bar{y}$=17.5

2) Locate the centroid of the shaded area shown



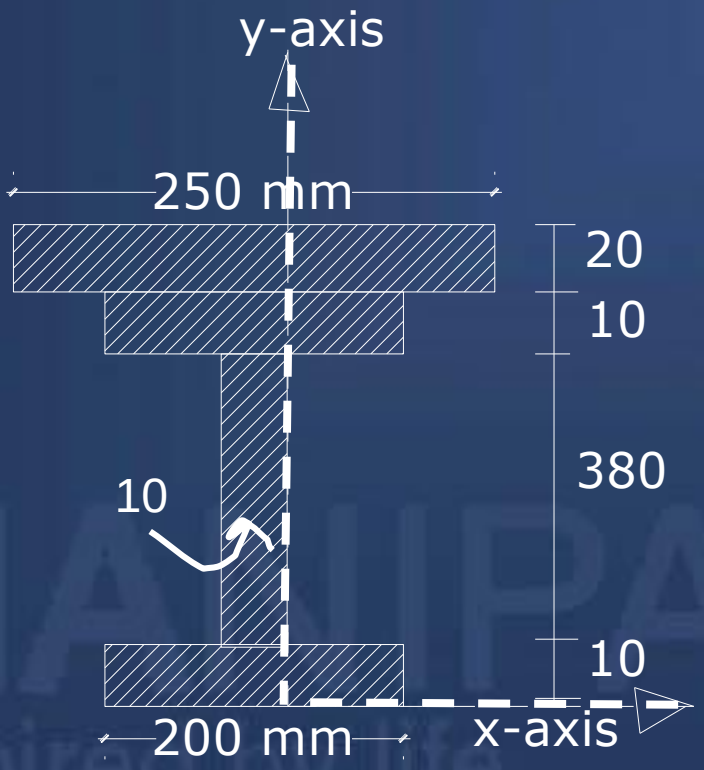
Ans: $\bar{x}$=474mm, $\bar{y}$=474mm

3) Locate the centroid of the shaded area w.r.t. to the axes shown



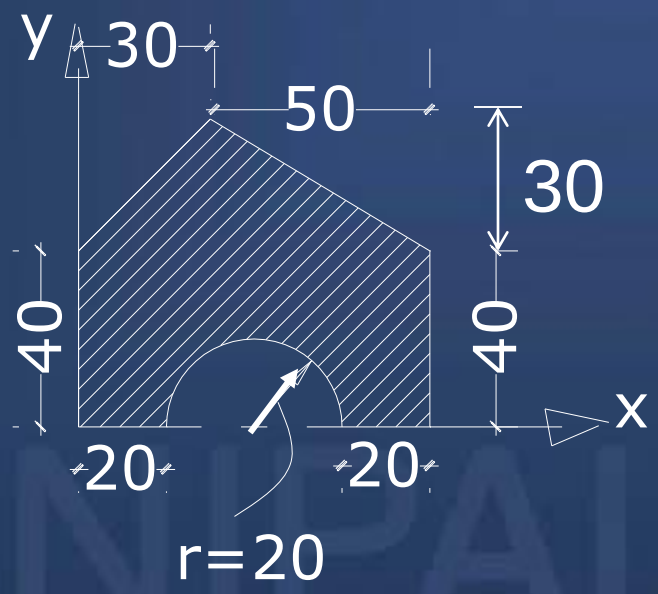
Ans: $\bar{x}$=34.4, $\bar{y}$=40.3

4) Locate the centroid of the shaded area w.r.t. to the axes shown



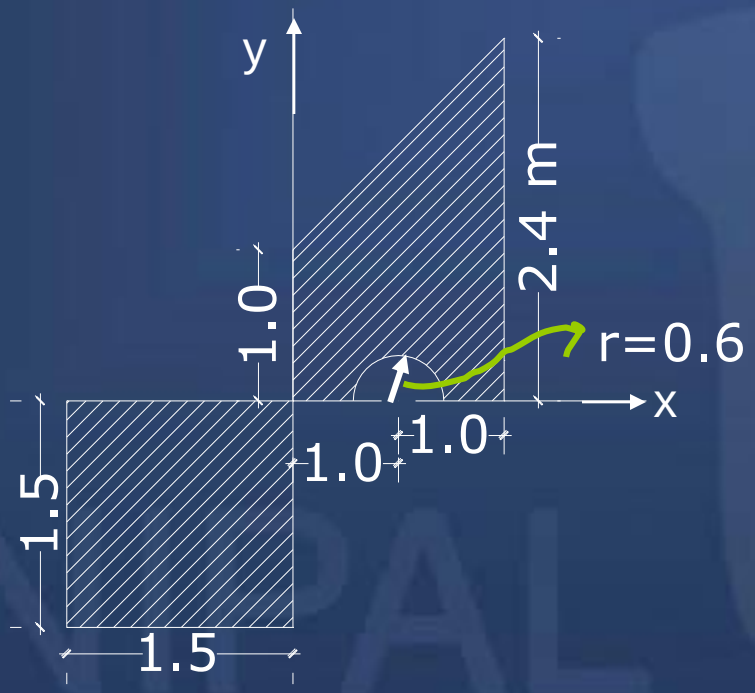
Ans: $\bar{x}$= -5mm, $\bar{y}$=282mm

5) Locate the centroid of the shaded area w.r.t. to the axes shown



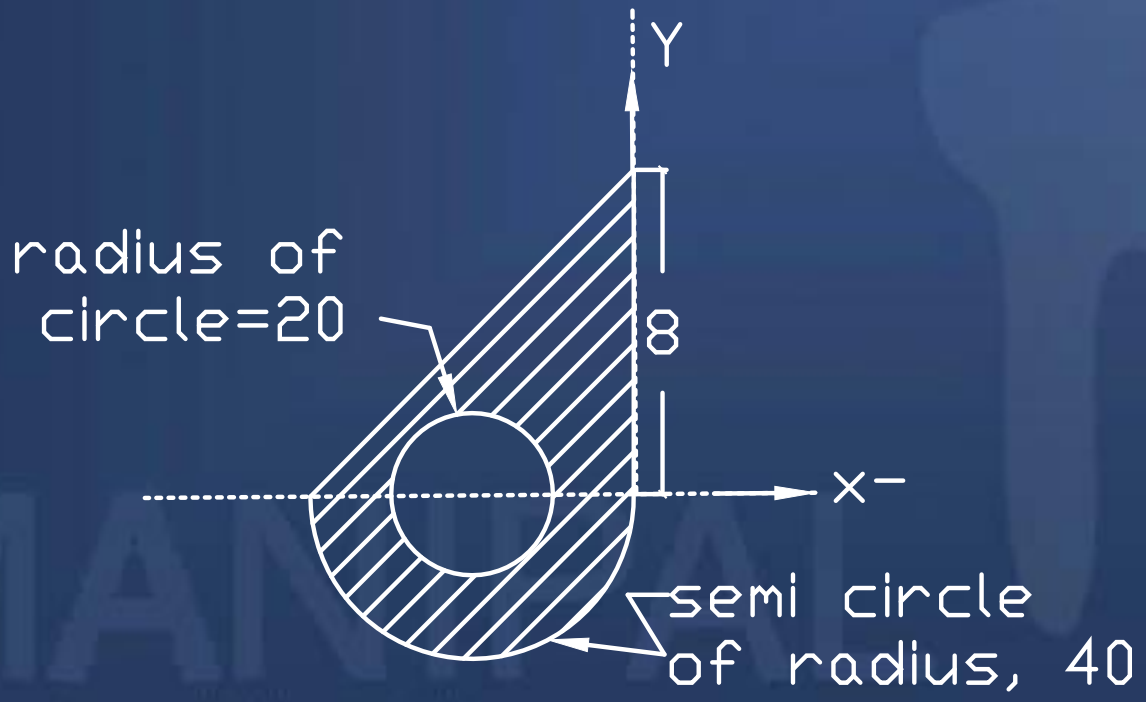
Ans: $\bar{x}$ =38.94, $\bar{y}$=31.46

6) Locate the centroid of the shaded area w.r.t. to the axes shown



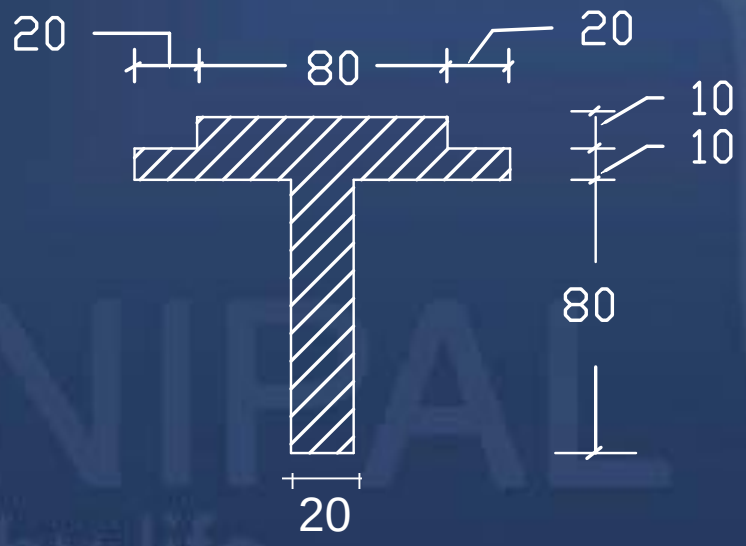
Ans: $\bar{x}$=0.817, $\bar{y}$=0.24

7) Locate the centroid of the shaded area w.r.t. to the axes shown



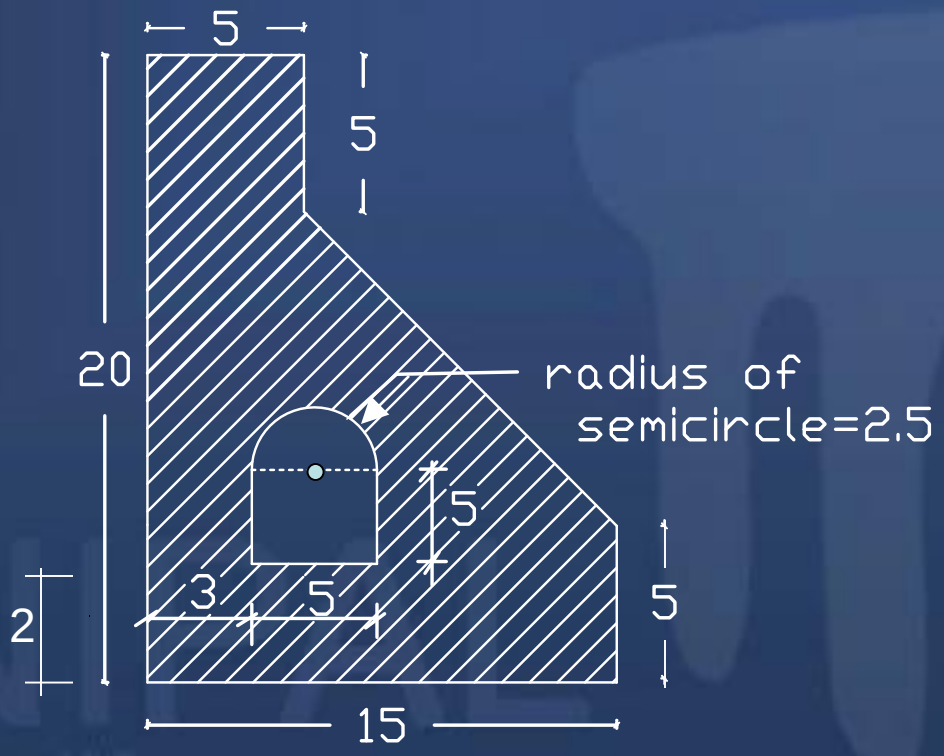
Ans: $\bar{x}$= -30.43, $\bar{y}$= +9.58

8) Locate the centroid of the shaded area.



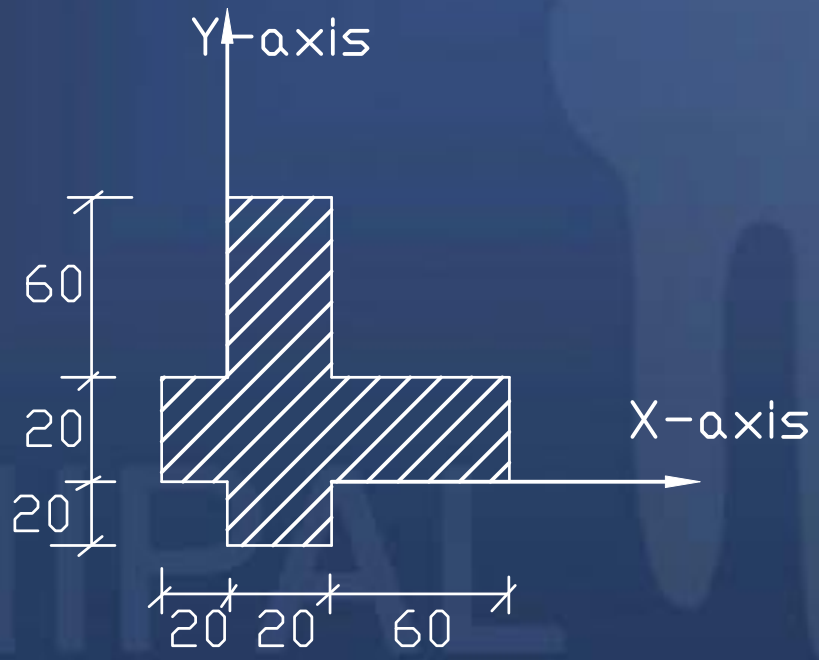
Ans: $\bar{x}$= 0, $\bar{y}$= 67.22(about base)

9) Locate the centroid of the shaded area w.r.t. to the base line.



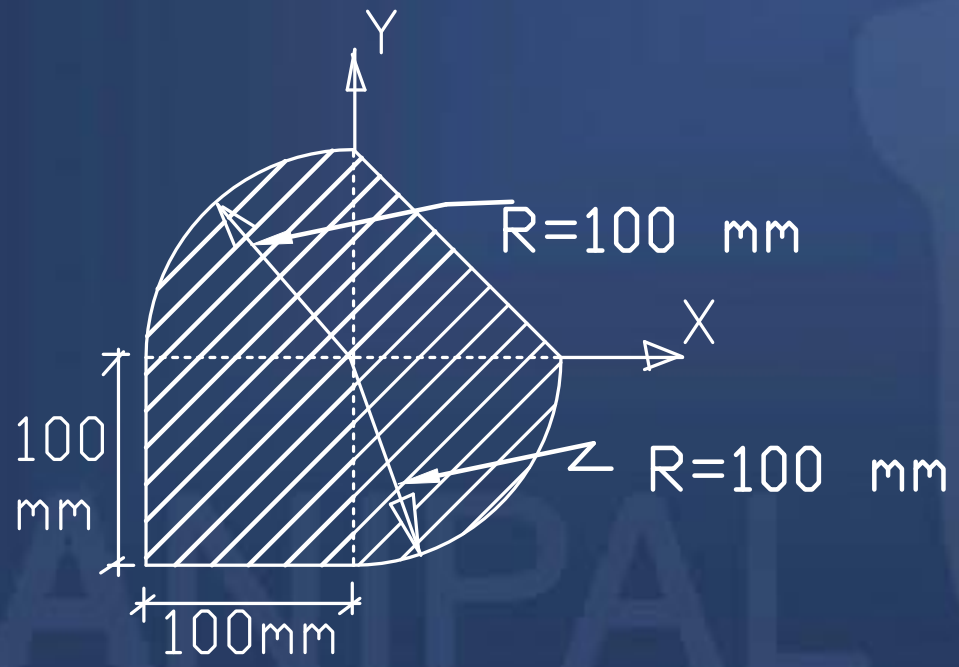
Ans: $\bar{x}$=5.9, $\bar{y}$= 8.17

10) Locate the centroid of the shaded area w.r.t. to the axes shown



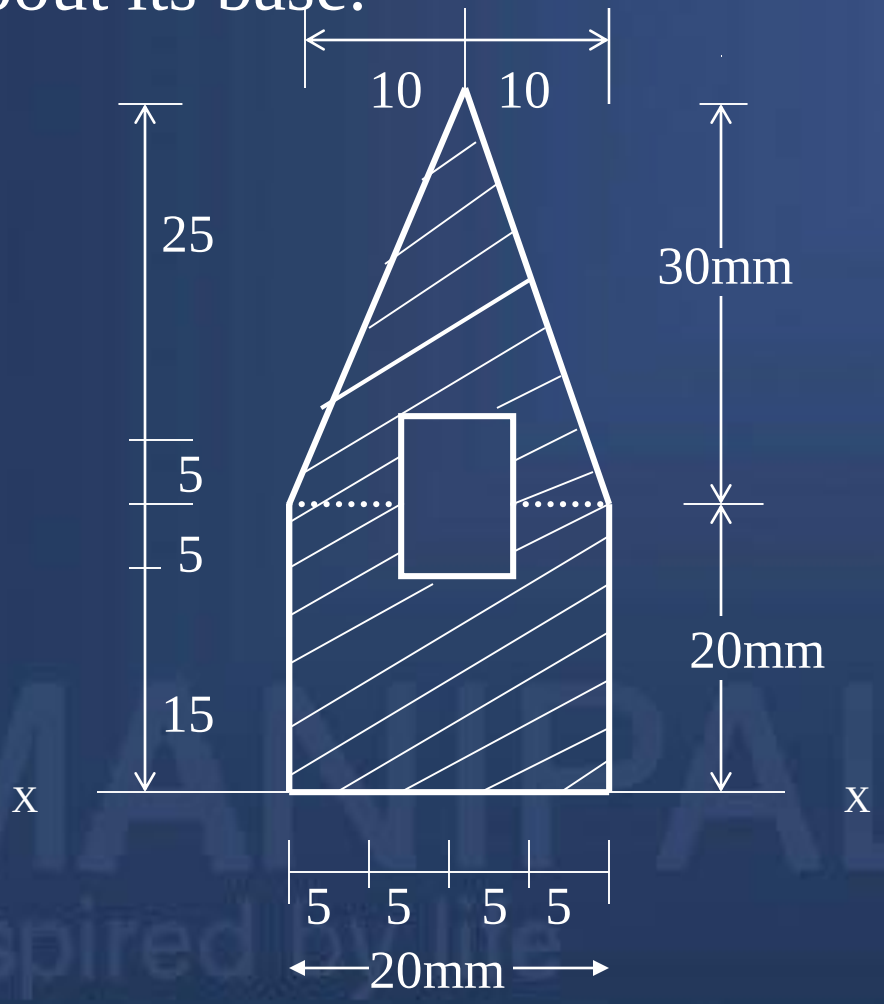
Ans: $\bar{x}$=21.11, $\bar{y}$= 21.11

11) Locate the centroid of the shaded area w.r.t. to the axes shown



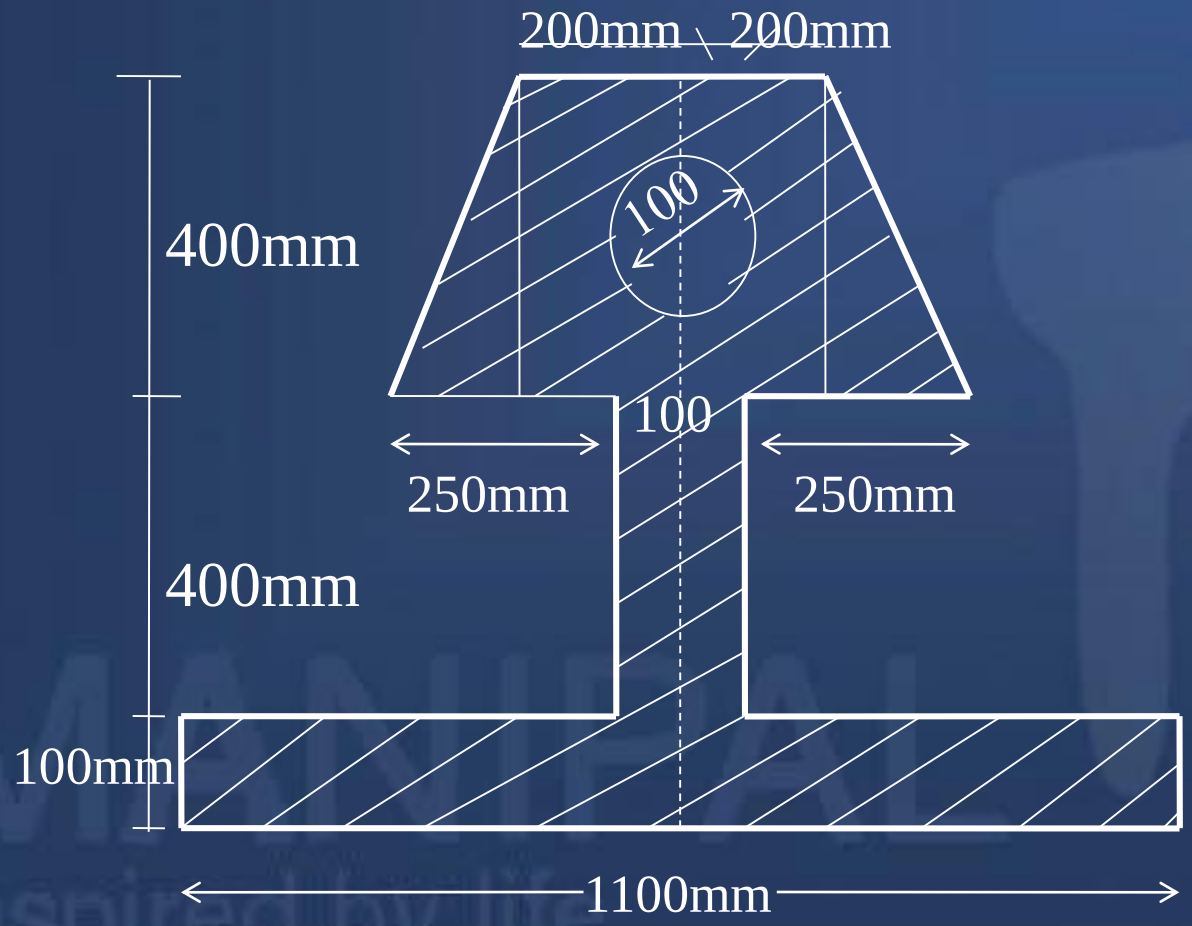
Ans: $\bar{x}= \bar{y}= 22.22$

Q.12. Find the moment of Inertia of the shaded area shown in fig.about its base.



ANS: $I_{xx} = 297.5 \times 10^3 mm4$

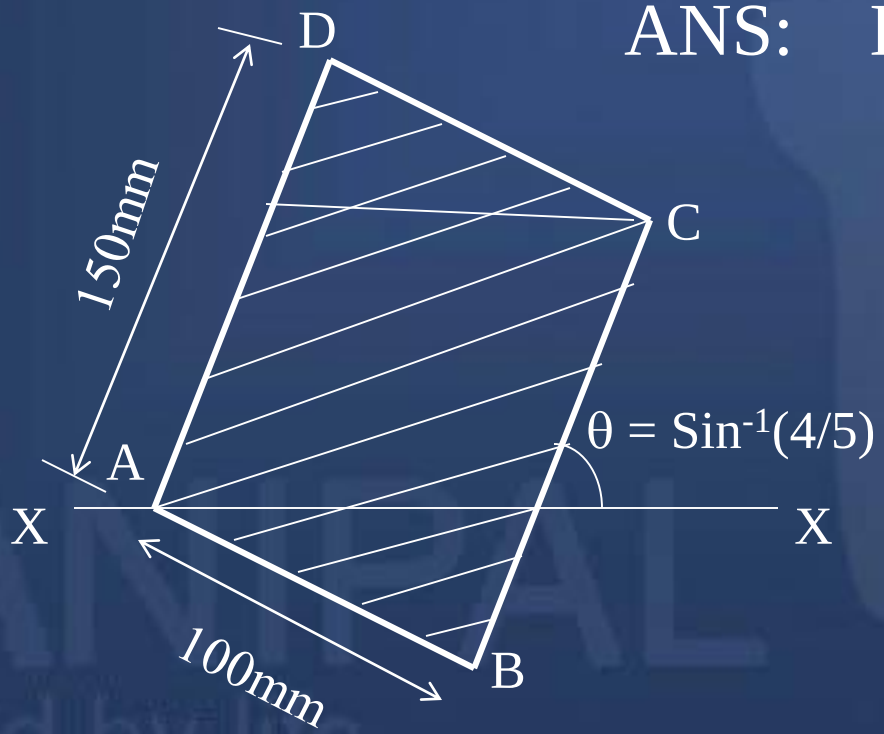
Q.13. Find M.I. about the horizontal centroidal axis for the area fig. No.3, and also find the radius of gyration.



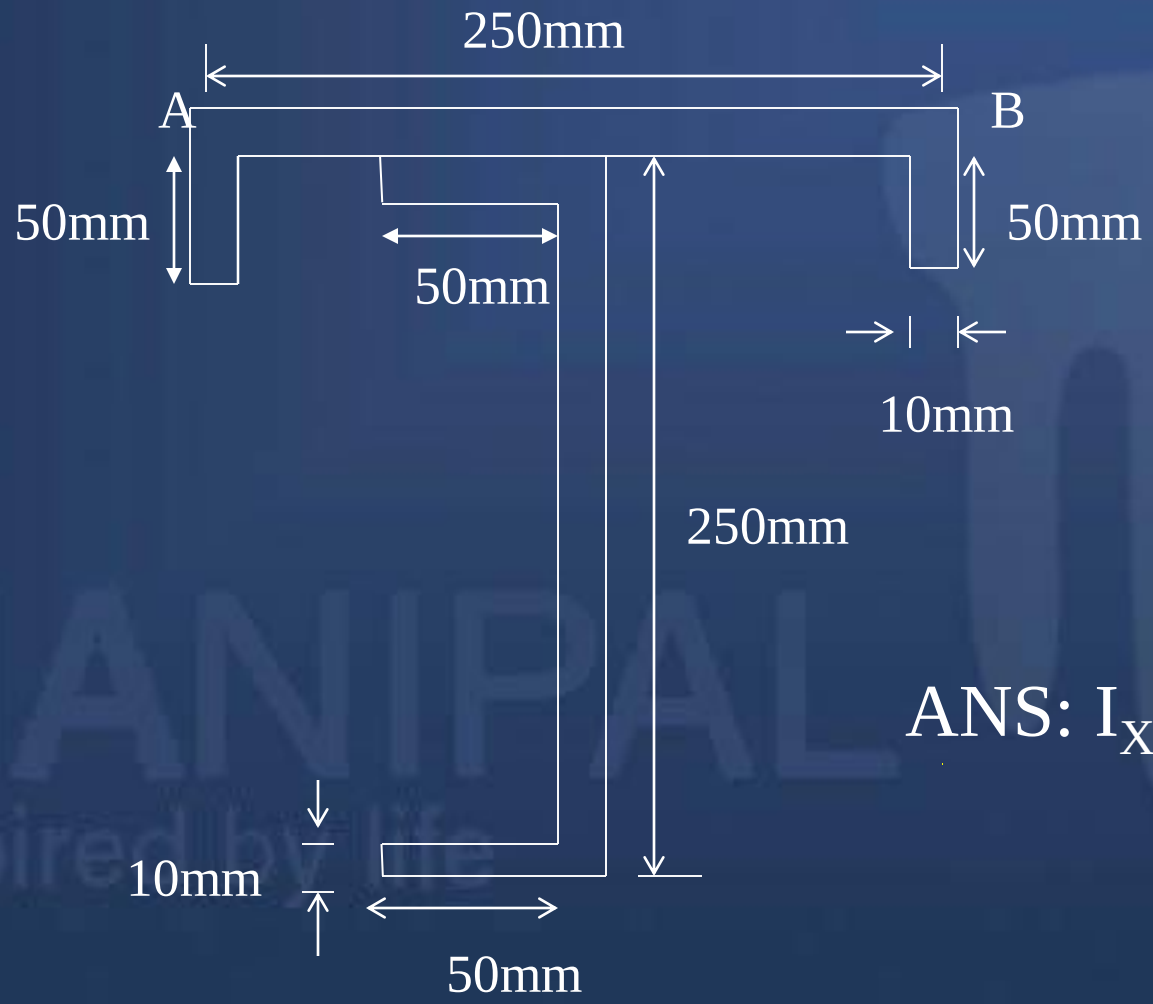
ANS: $y=436.5\text{mm}$ From bottom $I_{XX}=32.36*10^{9}\text{mm}^{4}$

Q. 14. Compute the M.I. of 100 mm x 150mm rectangular shown in fig.about x-x axis to which it is inclined at an angle of $\theta = \sin^{-1}(4/5)$

ANS: $I_{xx} = 36,00,000\ mm^4$

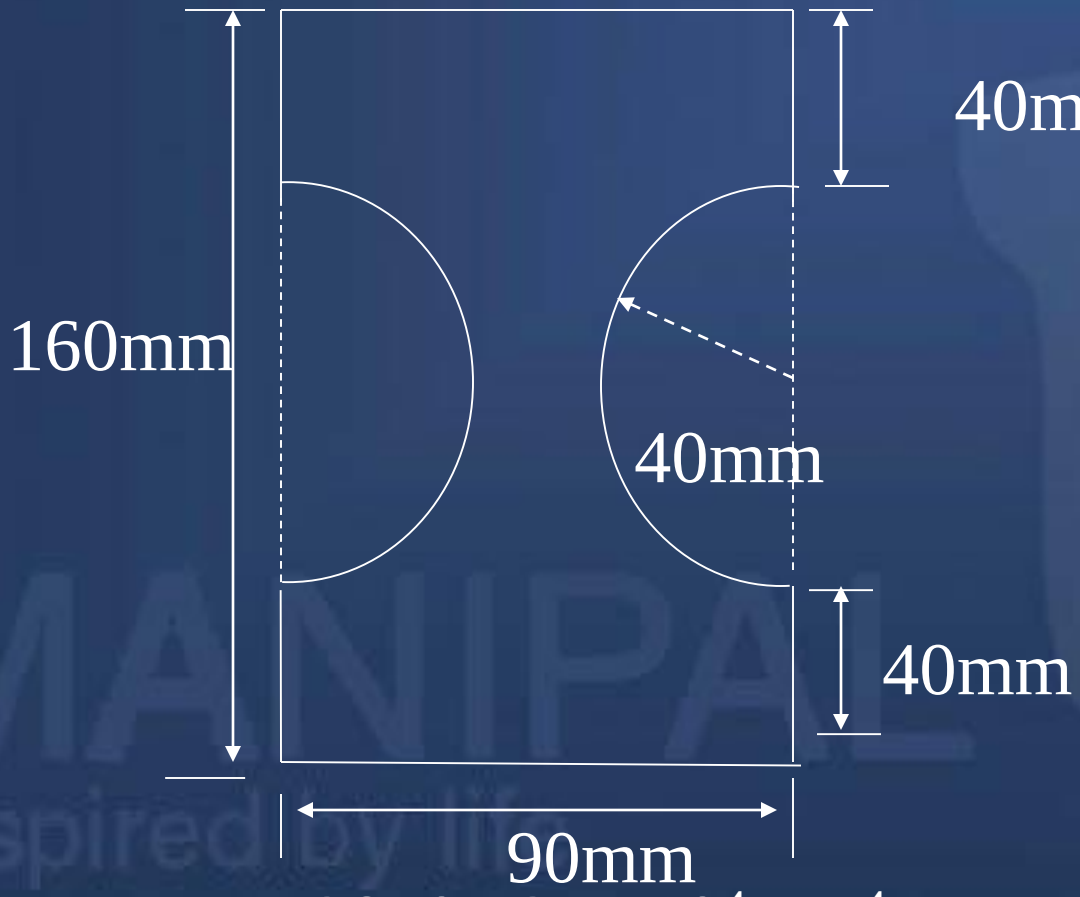


Q.15. Calculate the moment of inertia of the built- up section shown in fig.about the centroidal axis parallel to AB. All members are 10mm thick.



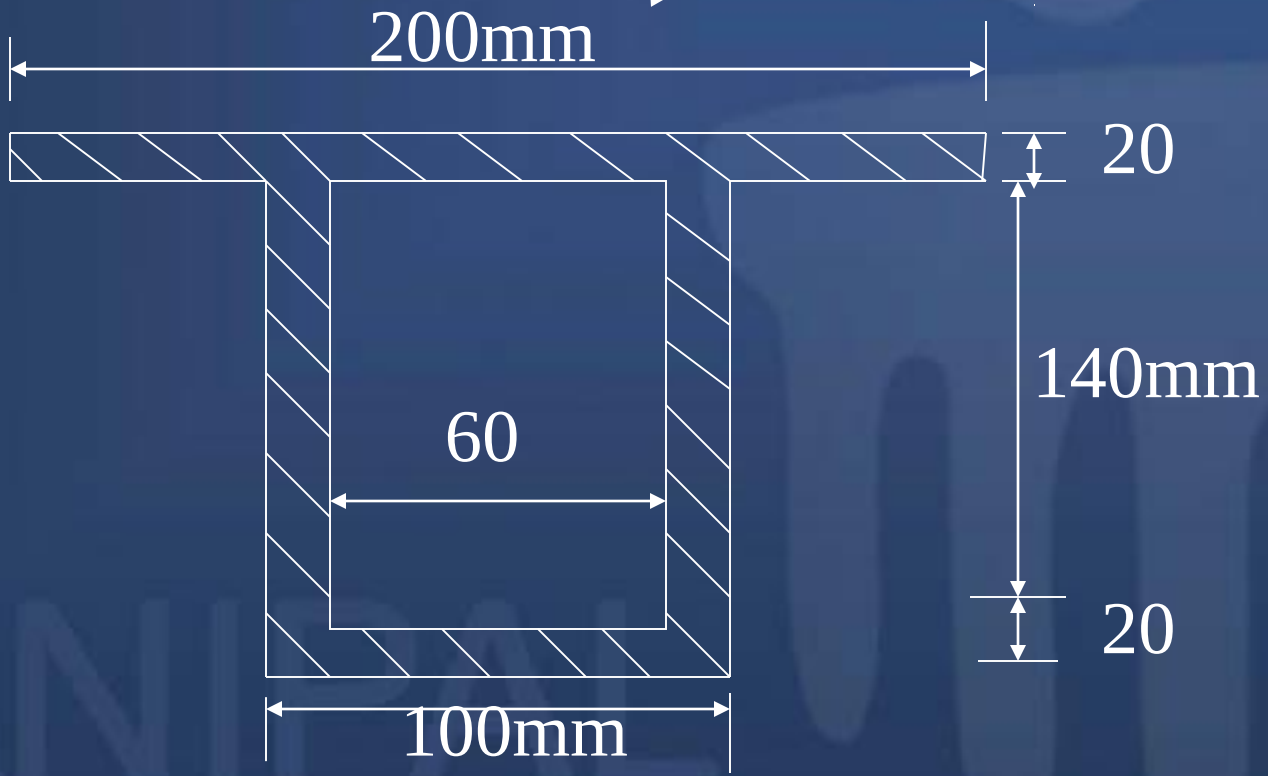
ANS: I_{XX} =5,03,99395mm

Q16. Determine horizontal and vertical centroidal M.I. for the section shown in figure.



[Ans: $I_{xx} = 2870.43 \times 10^4 mm^4$, $I_{yy} = 521.64 \times 10^4 mm^4$]

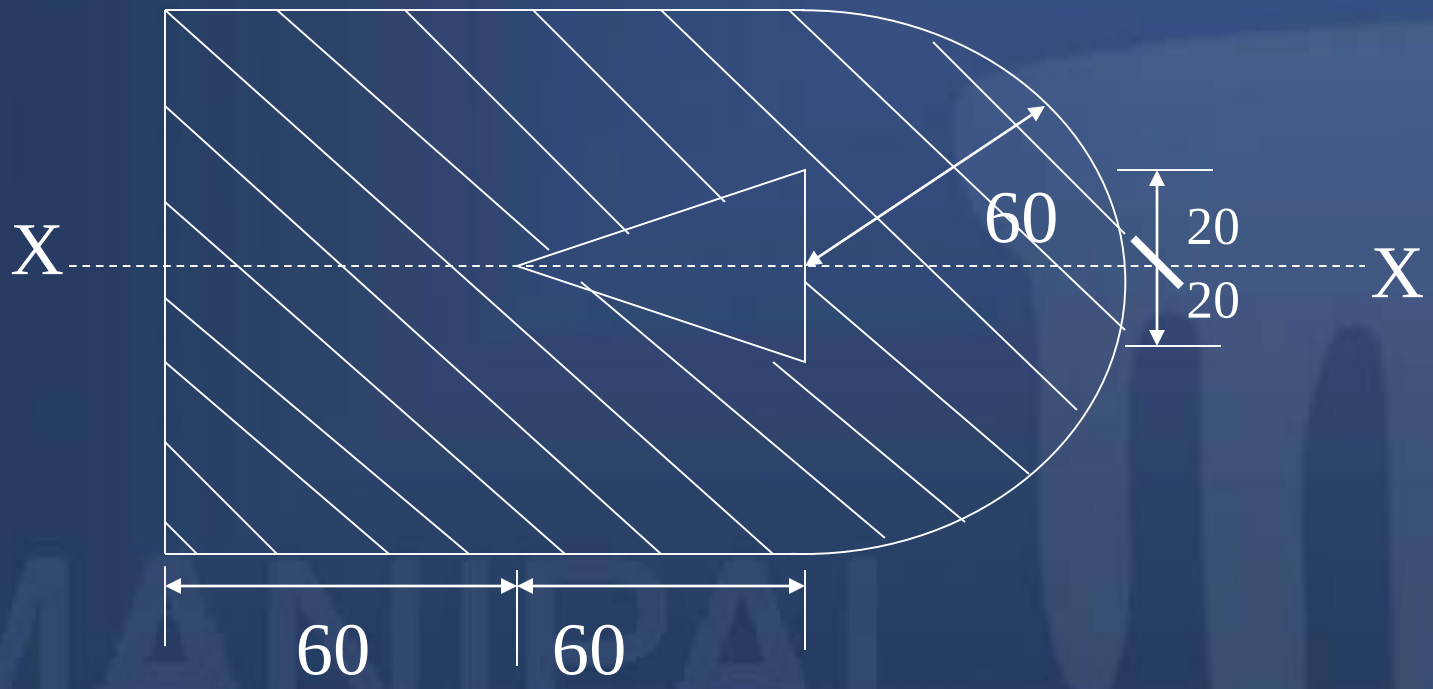
Q.17. Determine M.I. Of the built up section about the horizontal and vertical centroidal axes and the radii of gyration.



[Ans: $I_{xx} = 45.54 \times 10^6 mm^4$, $I_{yy} = 24.15 \times 10^6 mm^4$

$r_{xx} = 62.66mm$, $r_{yy} = 45.63mm$]

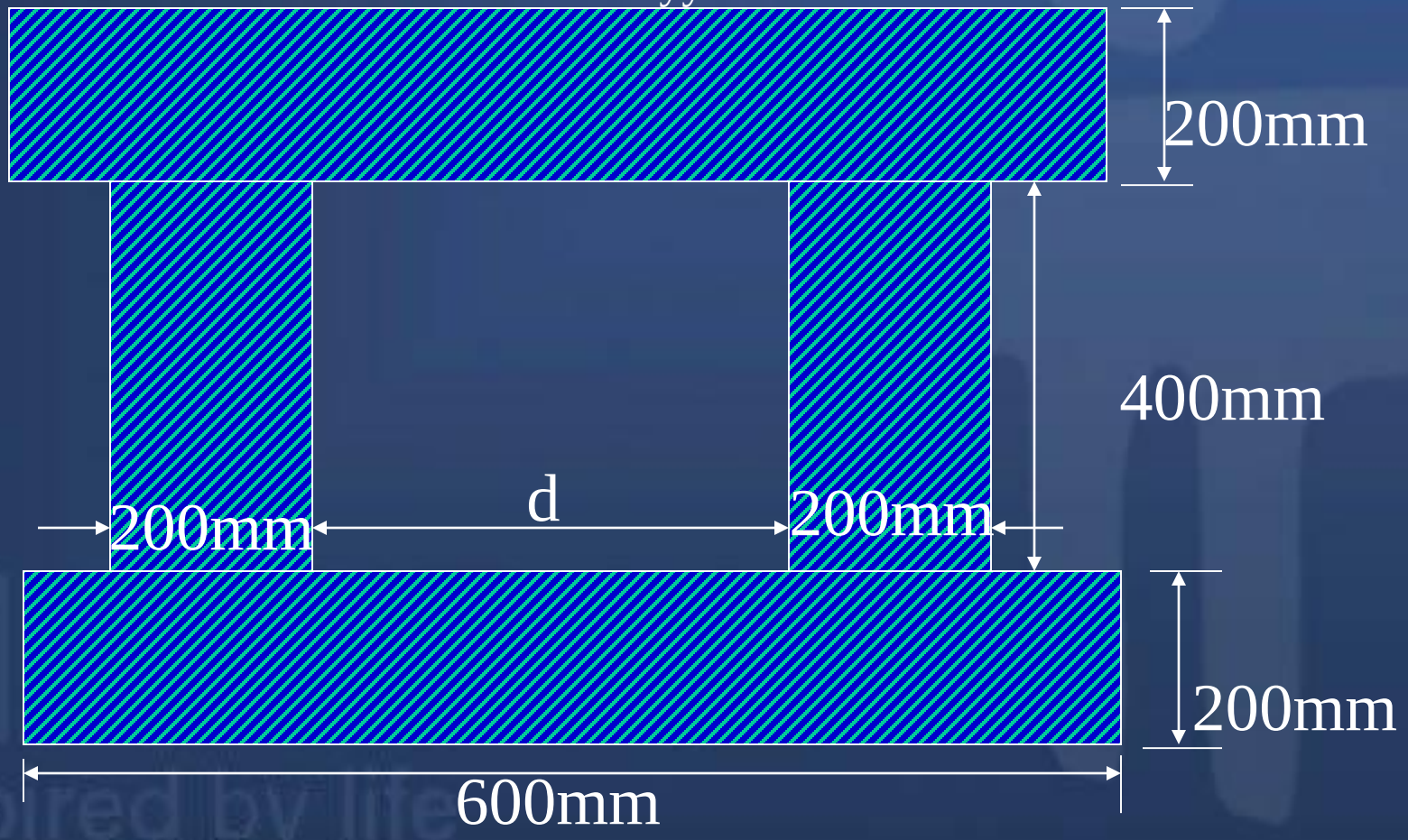
Q.18. Determine the horizontal and vertical centroidal M.I. Of the shaded portion of the figure.



[Ans: $\overline{X}$ = 83.1mm

$I_{xx} = 2228.94 \times 10^4 mm^4$, $I_{yy} = 4789.61 \times 10^4 mm^4$]

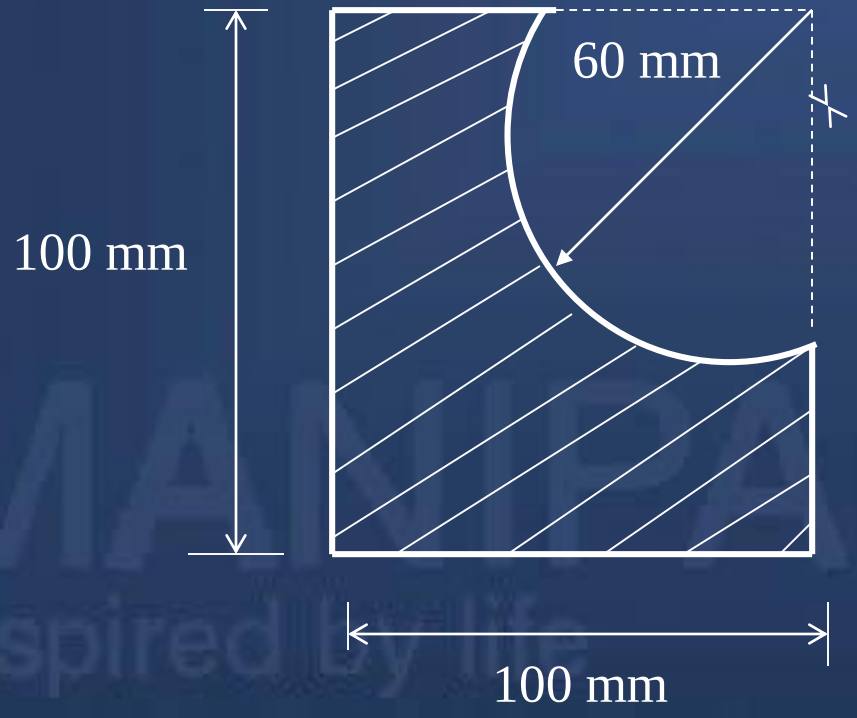
Q.19. Determine the spacing of the symmetrically placed vertical blocks such that $\overline{I_{xx}} = I_{yy}$ for the shaded area.



[Ans: d/2 = 223.9mm d=447.8mm]

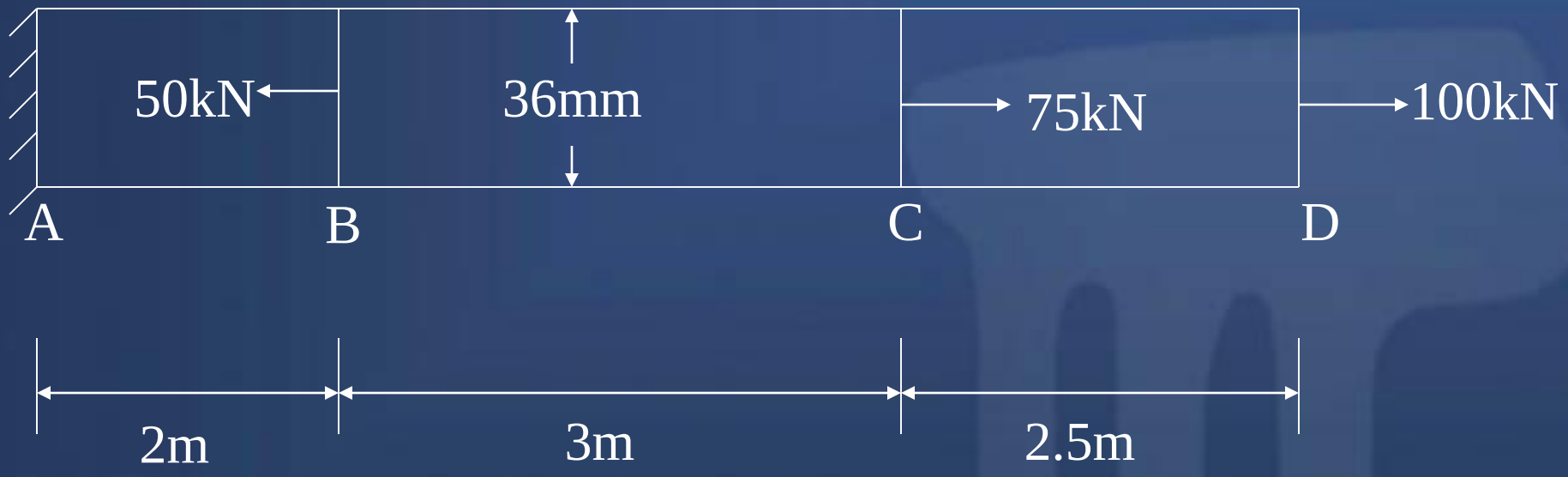
Q. 20. Determine he moment of inertia about the horizontal centroidal axes for the area in fig.

ANS: I_{XX}= =83,75,788.74mm^4



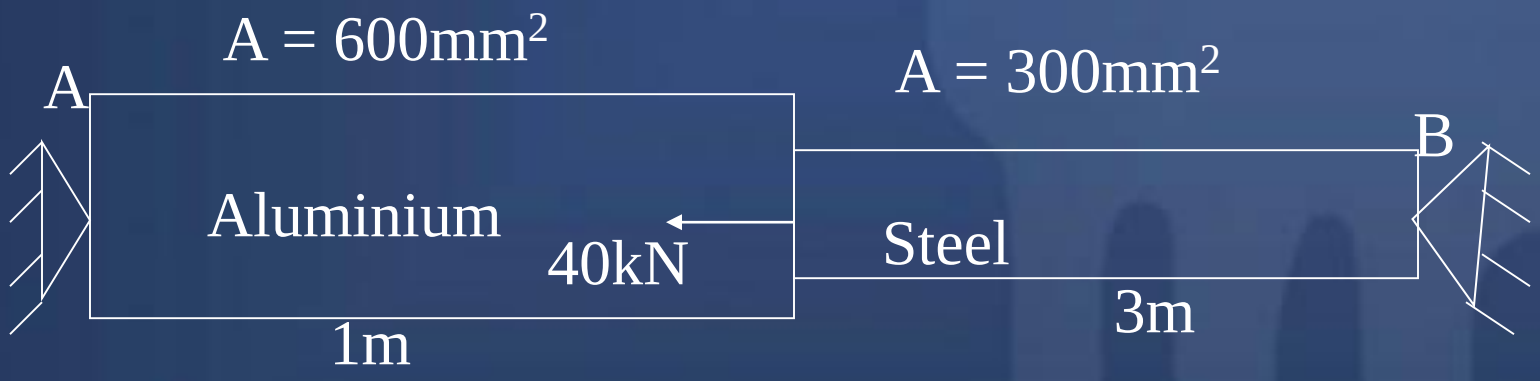
7) A steel rod ABC of 36mm diameter and brass rod CD of same diameter are joined at point C to form 7.5 m length. For the loading shown, determine the movement of Point B, C, D.

E_s =200GPa, E_b =105GPa



ANS: Movement of B = 1.23mm, Movement of C = 3.81mm,
Movement of D = 6.15mm

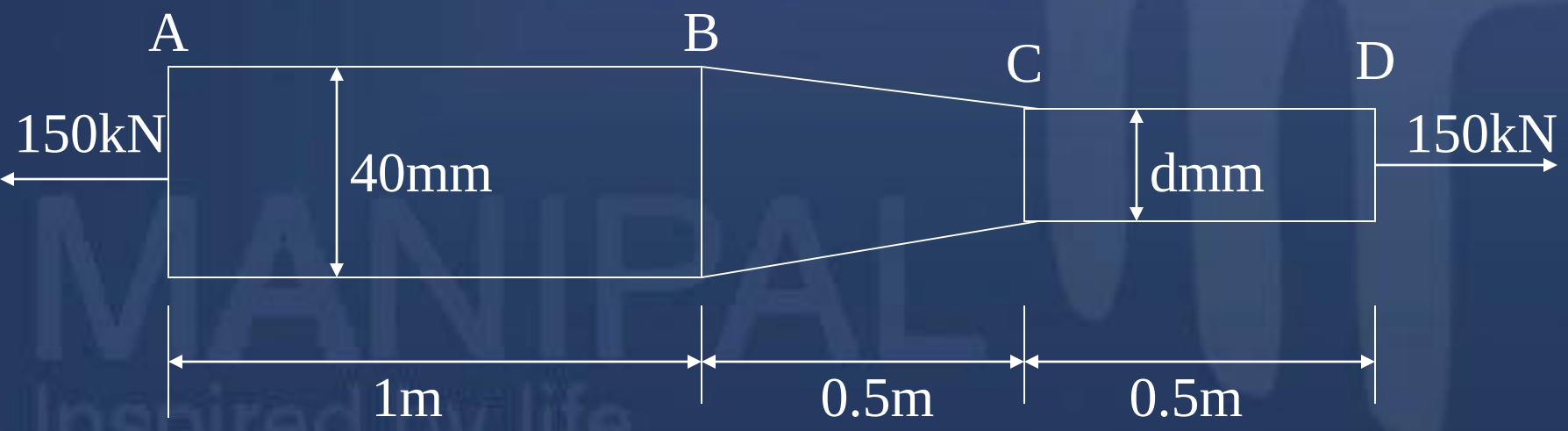
8) A composite bar is rigdly fixed at A and B . Determine the reaction at A and B and stresses in each bar. Take E_s=200GPa and E_{al} = 70GPa



ANS: R_A = 27.1KN, R_B = 12.9kN, σ_{al} = -45.16N/mm2, σ_{st} = 43N/mm2

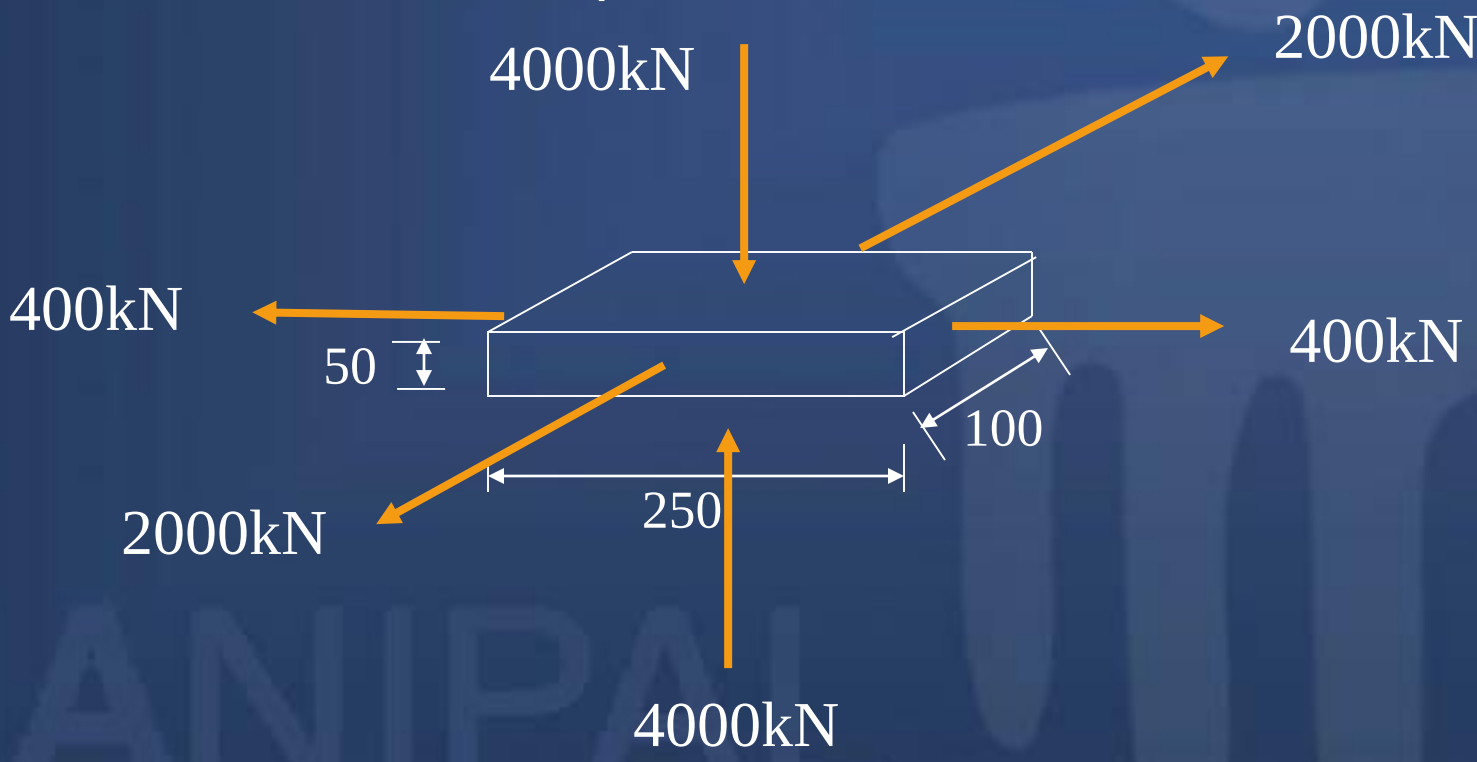
3) A 2m long steel bar is having a uniform diameter of 40mm for a length of 1m. In the next 0.5m diameter gradually decreases to dmm & for the remaining 0.5 m length, diameter remains dmm uniform. A load of 150kN is applied. If the total extension observed equal to 2.39mm Determine diameter of the bar.

ANS: d = 20mm



Simple Stresess and Strains, Compound Bars and Temperature Stress

1) A metallic bar 250mm×100mm×50mm is loaded as shown in the figure. Find the change in each dimension and total volume. Take E = 200GPa, Poisson's ratio, μ = 0.25



ANS:

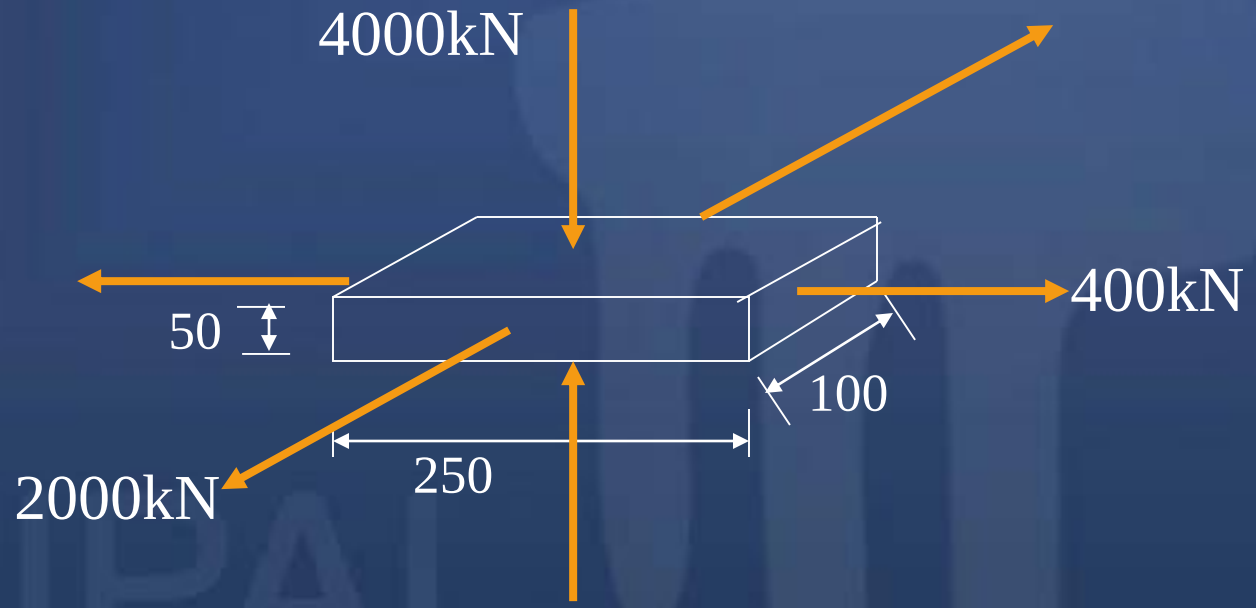
$\delta l_x = 0.1mm$

$\delta l_y = -0.005mm$

$\delta l_z = +0.09mm$

$\delta V = +250mm^3$

2) A metallic bar 250mm×100mm×50mm is loaded as shown in the Fig. shown below. Find the change in value that should be made in 4000kN load, in order that there should be no change in the volume of the bar. Take E = 200GPa, Poisson's ratio, μ = 0.25



ANS: P_y = -6000kN. The change in value should be an addition of 2000kN compressive force in Y-direction

3) A rectangular bar 50mm wide, 12mm thick and 300mm long is subjected to an axial pull of 84 kN. Determine (i) Change in length (ii) Change in width (iii) Change in thickness. (iv) Change in volume. Given E= 2×10^5 N/mm^2 , μ= 0.32. Ans: i) .21mm. ii) -1.12x10^{-2}mm.iii) -2.68x10^{-3}mm. iv) 45.36mm^3

4) A metal tube of external diameter 25mm and internal diameter 20mm was subjected to an axial load of 30kN. The extension on a guage length of 75mm was 0.06mm and decrease in outer diameter was 0.006mm.Find (i) Young's modulus. (ii) Poisson's ratio. (iii) Change in volume if length of the tube is 0.5m. ANS: i) 2.12x10^{5}N/mm^2 .ii) 0.3. iii) 28.27mm^3

5) A mild steel bar 200mm long 80mm×60mm in c/s is subjected to a longitudinal axial compression of 720kN. Determine value of lateral forces necessary to prevent any transverse strain. Also determine alteration in length. Given E=200GPa, μ= 0.25. ANS: P_y= 6x10^{5}N.dl= 0.125mm

6) A bar of certain material 50 mm square is subjected to an axial pull of 150KN. The extension over a length of 100mm is 0.05mm and decrease in each side is 0.0065mm. Calculate (i) E (ii) μ (iii) G (iv) K

ANS: E =1.2 x 10^{5}MPa (ii) μ = 0.26 (iii)G= 0.47 ×10^{5}MPa (iv)K = 8.3 × 10^{4}N/mm^2

7 The maximum safe compressive stress in a hardened steel punch is limited to 1000MPa, and the punch is used to pierce circular holes in mild steel plate 20mm thick. If the ultimate shearing stress is 312.5MPa, calculate the smallest diameter of hole that can be pierced.

Ans: 25mm

8) A rectangular bar of 250mm long is 75mm wide and 25mm thick. It is loaded with an axial tensile load of 200kN, together with a normal compressive force of 2000kN on face 75mm×250mm and a tensile force 400kN on face 25mm×250mm. Calculate the change in length, breadth, thickness and volume. Take E = 200GPa & μ=0.3

Ans: 0.15,0.024,0.0197mm, $60mm^3$

9 A piece of 180mm long by 30mm square is in compression under a load of 90kN as shown in the figure. If the modulus of elasticity of the material is 120GPa and Poisson's ratio is 0.25, find the change in the length if all lateral strain is prevented by the application of uniform lateral external pressure of suitable intensity.

Ans: 0.125mm

10 The diameter of a specimen is found to reduce by 0.004mm when it is subjected to a tensile force of 19kN. The initial diameter of the specimen was 20mm. Taking modulus of rigidity as 40GPa determine the value of E and μ

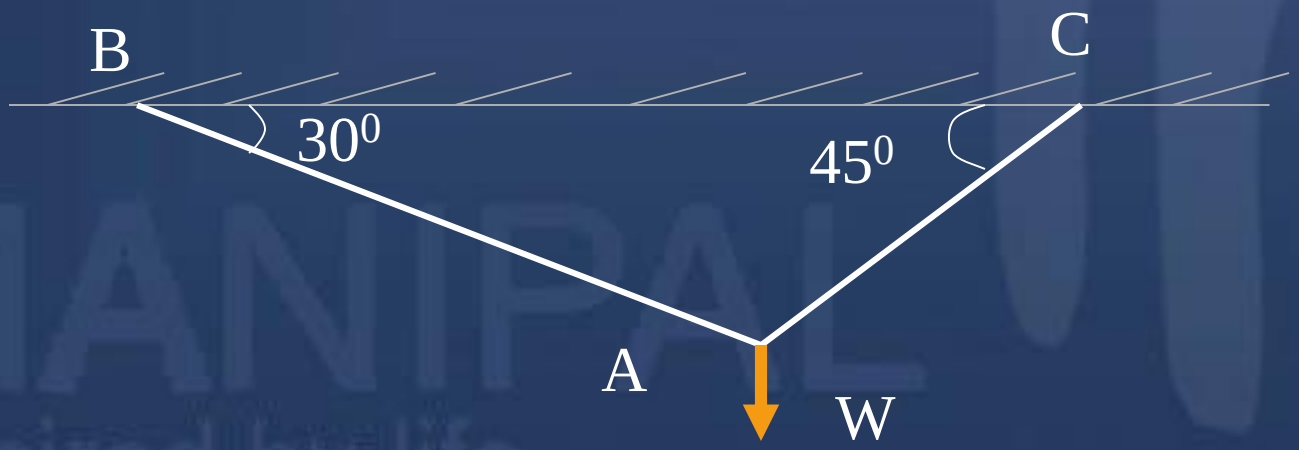
Ans: E=110GPa, μ=0.36

11 A circular bar of brass is to be loaded by a shear load of 30kN. Determine the necessary diameter of the bars (a) in single shear (b) in double shear, if the shear stress in material must not exceed 50MPa.

Ans: 27.6, 19.5mm

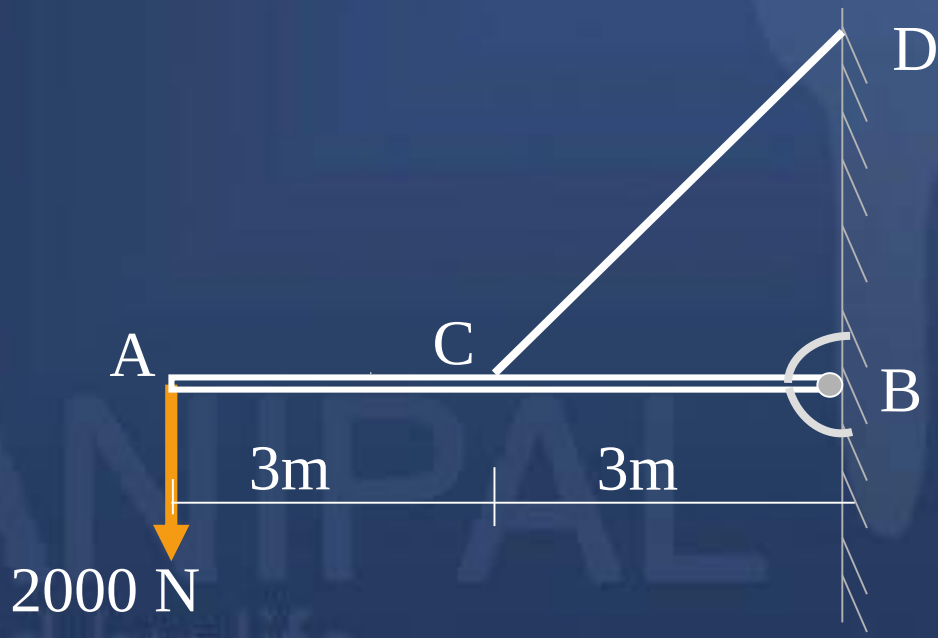
12 Determine the largest weight W that can be supported by the two wires shown. Stresses in wires AB and AC are not to exceed 100MPa and 150MPa respectively. The cross sectional areas of the two wires are 400mm^2 for AB and 200mm^2 for AC.

Ans: 33.4kN

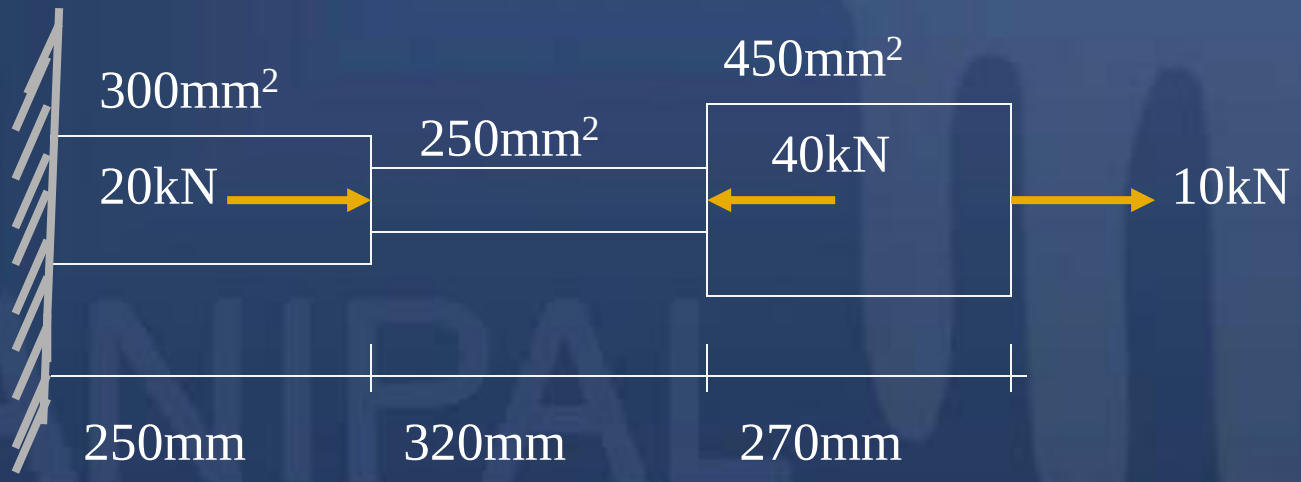


13 A homogeneous rigid bar of weight 1500N carries a 2000N load as shown. The bar is supported by a pin at B and a 10mm diameter cable CD. Determine the stress in the cable

Ans: 87.53MPa



14. A stepped bar with three different cross-sectional areas, is fixed at one end and loaded as shown in the figure. Determine the stress and deformation in each portions. Also find the net change in the length of the bar. Take E = 200GPa



Ans: -33.33, -120, 22.2MPa, -0.042, -0.192, 0.03mm, -0.204mm

15) A brass rod 20mm diameter enclosed in a steel tube of 25mm internal diameter & 10mm thick. The bar & the tube are initially 2m long & rigidly fastened at both the ends. The temperature is raised from 20^0C to 80^0C. Find the stresses in both the materials.

If the composite bar is then subjected to an axial pull of 50kN, find the total stress. E_s=200GPa, E_b=80GPa, $\alpha_s=12\times10^{-6}/^0$C, $\alpha_b=19\times10^{-6}/^0$C.

ANS: σ_b=8.81N/mm^2 (C) , σ_s=47.99N/mm^2(T)

16) A bar 800mm long is rigidly attached at A & B. Forces of 300kN & 600kN acts as shown. If E= 200GPa, determine reaction at A & B.

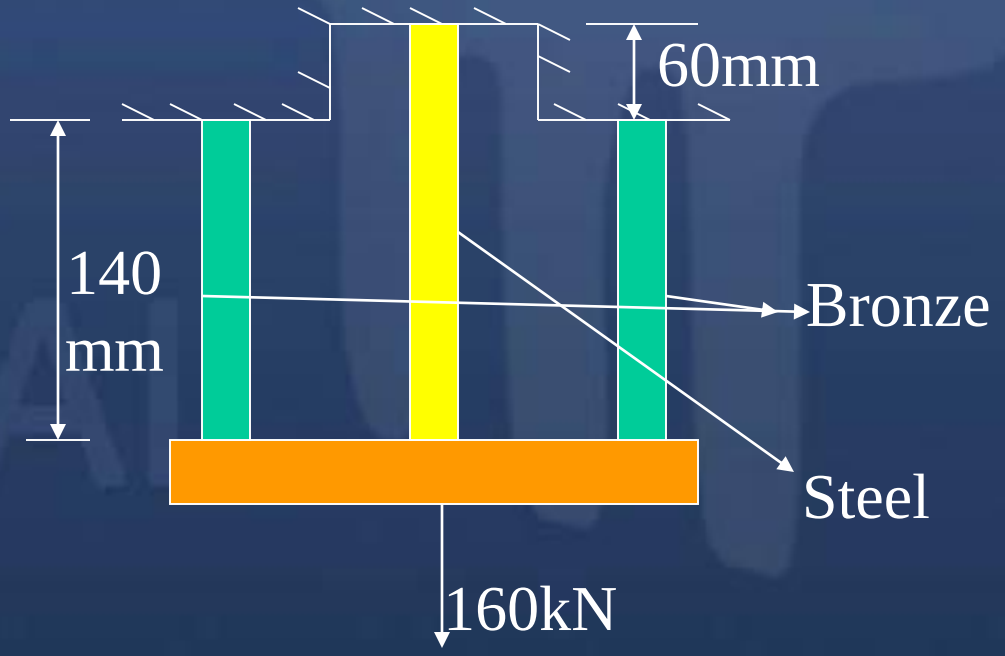
R_A=84.38kN,
R_B=215.63kN

17) A circular concrete pillar consists of six steel rods of 22mm diameter each reinforced into it. Determine the diameter of pillar required when it has to carry a load of 1000kN. Take allowable stresses for steel & concrete as 140Mpa & 8Mpa respectively. The modular ratio is 15 ANS: D=344.3mm

18) A cart wheel of 1.2m diameter is to be provided with steel tyre. Assume the wheel to be rigid. If the stress in steel does not exceed 140MPa, calculate minimum diameter of steel tyre & minimum temperature to which it should be heated before on to the wheel.

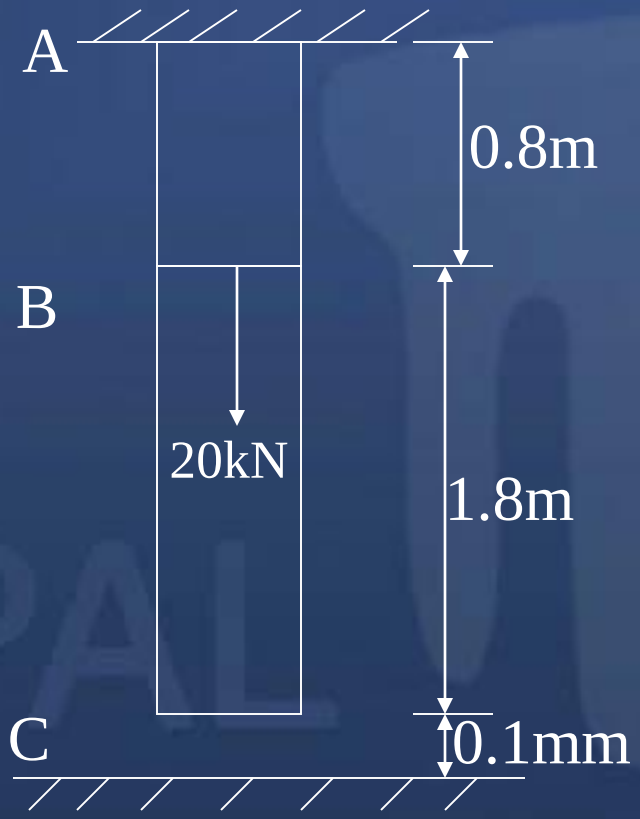
ANS: d=1199.16mm T=58.33^{0}C

19) Determine the stresses & deformation induced in Bronze & steel as shown in figure. Given A_s=1000mm^2, A_b=600mm^2, E_s= 200Gpa, E_b= 83Gpa . ANS:(σ_b=55Mpa, σ_s=93.5Mpa, $dL_s=dL_b$=0.093mm)



20)A circular bar of 250mm^2 c/s and 2.6 m in length is rigidly fixed at its top in vertical position. An axial force of 20kN is applied vertically down wards at a distance of 0.8m from the upper support. If there is a initial gap of 0.1mm b/w the lower support and bottom surface of the member, determine the stresses and deformation induced in the portions AB and BC. Take E = 200GPa.

ANS: σ_{AB} = 63.08N/mm^2(T), σ_{BC} = 16.92N/mm^2(C)



Thin Cylinder

PROBLEM 1:

Calculate the circumferential and longitudinal strains for a boiler of 1000mm diameter when it is subjected to an internal pressure of 1MPa. The wall thickness is such that the safe maximum tensile stress in the boiler material is 35 MPa. Take E=200GPa and μ= 0.25.

(Ans: ε_C=0.0001531, ε_L=0.00004375)

2.A copper tube having 45mm internal diameter and 1.5mm wall thickness is closed at its ends by plugs which are at 450mm apart. The tube is subjected to internal pressure of 3 MPa and at the same time pulled in axial direction with a force of 3 kN. Compute: i) the change in length between the plugs ii) the change in internal diameter of the tube. Take E_{CU} = 100 GPa, and μ = 0.3.

PROBLEM 3:

A gravity main 2m in diameter and 15mm in thickness. It is subjected to an internal fluid pressure of 1.5 MPa. Calculate the hoop and longitudinal stresses induced in the pipe material.

(Ans: σ_C=100 MPa, σ_L=50 MPa,)

PROBLEM 4:

At a point in a thin cylinder subjected to internal fluid pressure, the value of hoop strain is 600×10^{-4} (tensile). Compute hoop and longitudinal stresses. Take E=200GPa and μ= 0.2857.

(Ans: σ_C=140 MPa, σ_L=70 MPa,)

PROBLEM 5:

A cylindrical tank of 750mm internal diameter and 1.5m long is to be filled with an oil of specific weight 7.85 kN/m3 under a pressure head of 365 m. If the longitudinal joint efficiency is 75% and circumferential joint efficiency is 40%, find the thickness of the tank required. Also calculate the error of calculation in the quantity of oil in the tank if the volumetric strain of the tank is neglected. Take permissible tensile stress as 120 MPa, E=200GPa and μ= 0.3 for the tank material. (Ans: t=12 mm, error=0.085%.)