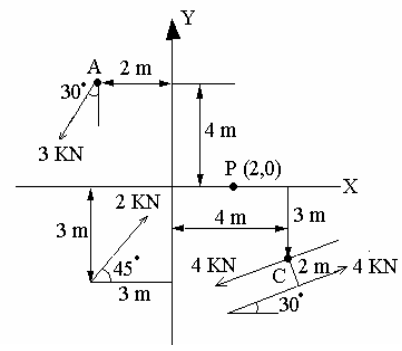
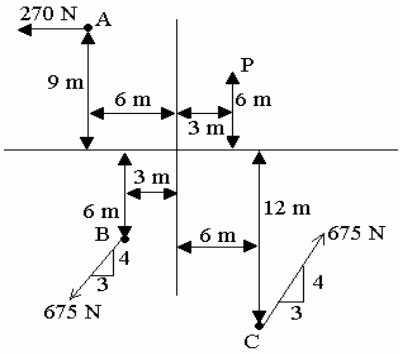
EQUIVALENT FORCE SYSTEMS

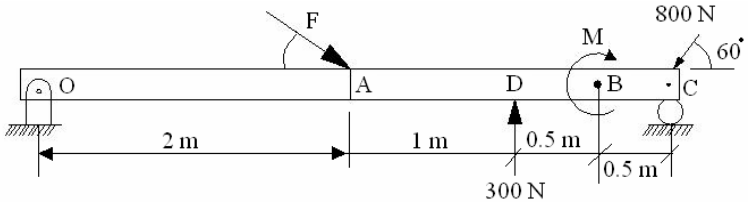
1. Replace the force and couple system by an equivalent single force and couple acting at point P.

Ans: (a) –0.086i-1.184 kN , 21.6 kN m (b) –270 N, 6885 kN m



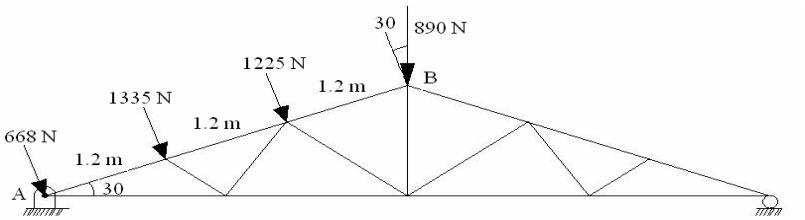


2. Determine the magnitude and direction θ of force F and the couple moment M such that the loading system is equivalent to a resultant force of 600N, acting vertically downward at O, and a clockwise moment of 400 N-m. *Ans: 450.5 N, 27.4^{O}, 1714 N m*



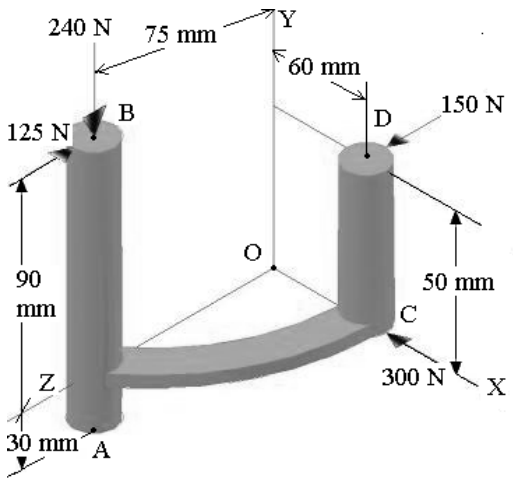
3. The systems of four forces acts on the roof truss determine the resultant force and specify its location along AB measured from point P.

Ans: 1.83m



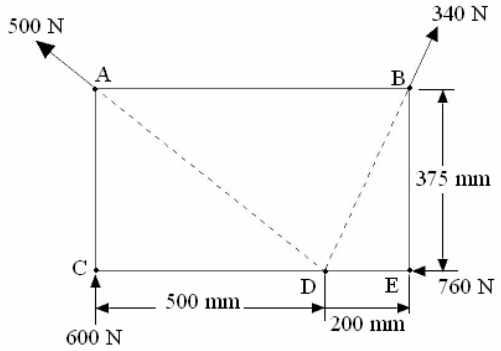
4. A machine component is subjected to the forces shown each of which is parallel to one of the co-ordinate axis. Replace these forces by an equivalent force- couple system at A.

Ans: -300i-240j+25k N, -3i+13.5j+9k N m



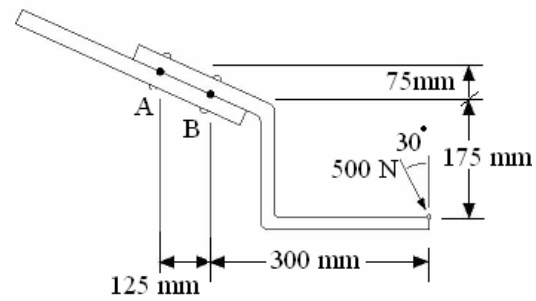
5. Four forces act on a 700mm x 375 mm plate as shown. (a) Find the resultant of these forces. (b) Locate the two points where the line of action of the resultant intersects the edge of the plate.

Ans: -1000i+1200j N, (250,300) from C



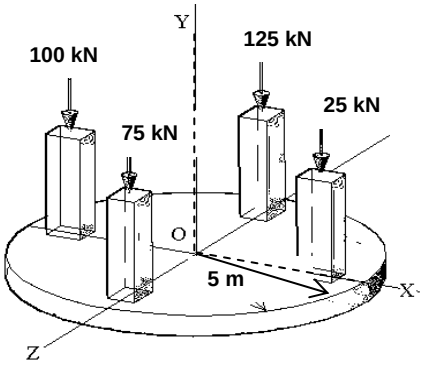
6. A 500- N force is applied to a bent plate as shown. Determine (a) An equivalent force- couple system at B, (b) Equivalent systems formed by a vertical force A and a force at B.

Ans: (a) 500N / 60^o , 86 N m (b) A=689 N, B= 1150 / 77.4^o



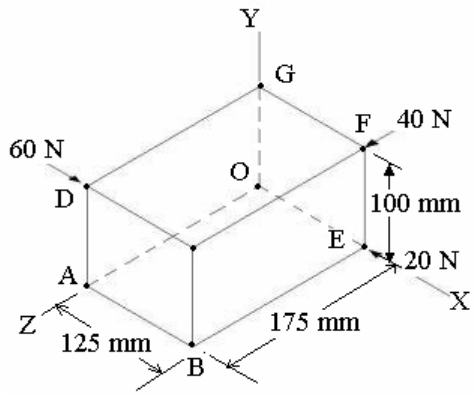
7. A concrete foundation mat of 5-m radius supports four equally spaced columns, each of which is located 4m from the center of the mat. Determine the magnitude and the point of application of the resultant of the four loads.

Ans: 325 N; (-0.92,-0.62)m

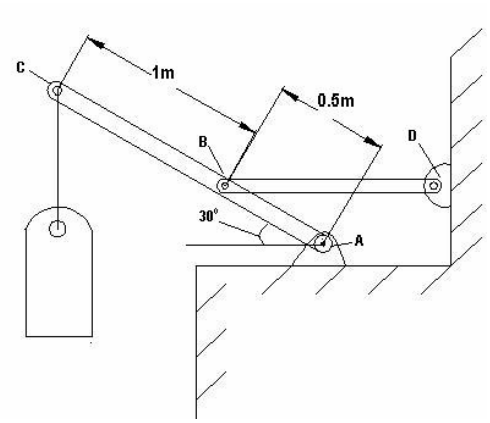


8. A rectangular block is acted upon by the three forces, which are directed along its edges. Replace these forces by an equivalent force system at O and determine the magnitude and the direction of the resultant force R.

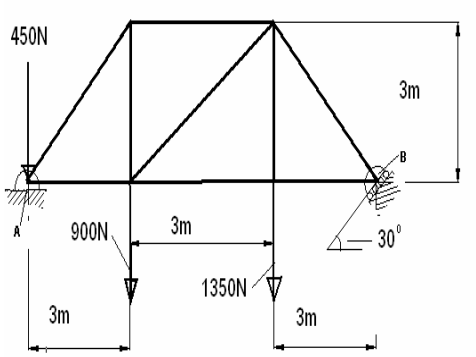
Ans: (4i+5.5j-6k) Nm



FREE BODY DIAGRAMS AND STATIC ANALYSIS

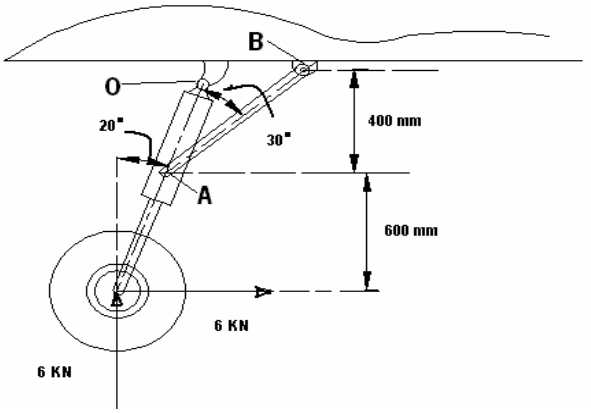


1. Consider the uniform rod ABC supported by a pin at A and short link BD. draw the free- body diagrams and determine the total number of unknown force and couple magnitudes and/or directions. Neglect the weight of the members.



2. Determine the horizontal and vertical components of reaction at the pin A and the reaction at the roller support B required for equilibrium of the truss.

Ans: A=683i + 1500j N, B=1386 N

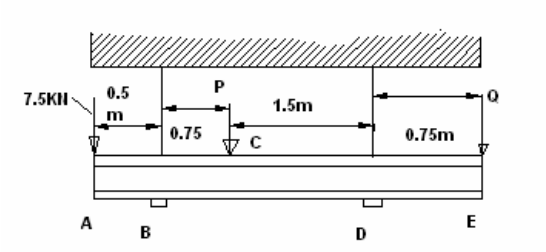


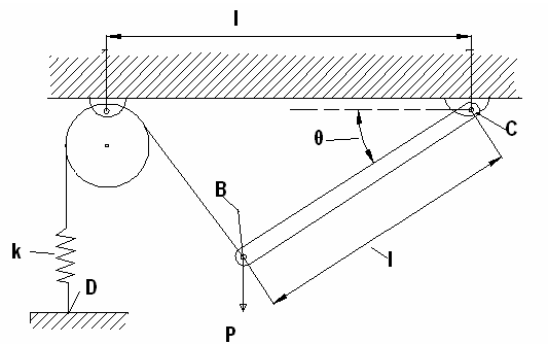
3. As an airplane's brakes are applied, the nose wheel exerts two forces on the end of the landing gear as shown. Determine the x and y components of reaction at the pin C and the force in strut AB.

Ans: F_{AB} = 865 N , C=2.7i + 6.6j kN

4. Three loads are applied to a light beam supported by cables attached at B and D knowing that the maximum allowable tension in each cable is 12KN and neglecting the weight of the beam, determine the range of values of Q for which the loading is safe when P = 5KN.

Ans: $1.5kN \leq Q \geq 9kN$

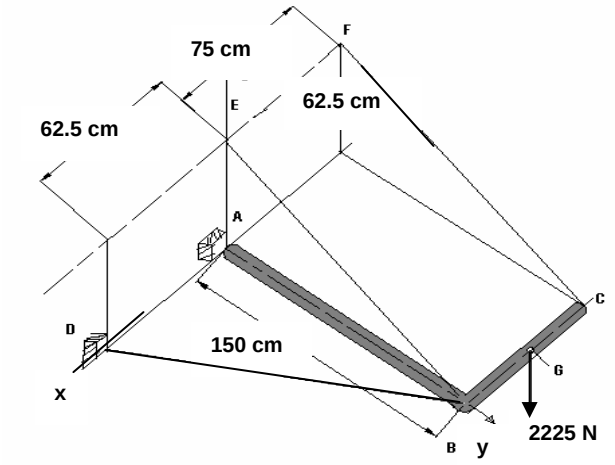




5. A vertical load P is applied at the end B of rod BC. The constant of the spring is K and the spring is outstretched when θ = 0. (a) Neglecting the weight of the rod, express the angle θ corresponding to the equilibrium position in terms of P, K and l. (b) Determine the value of θ corresponding to the equilibrium if P = 2kl. *Ans: $\theta = \tan^{-1}(P/Kl)$, $\theta = 63.44^0$*

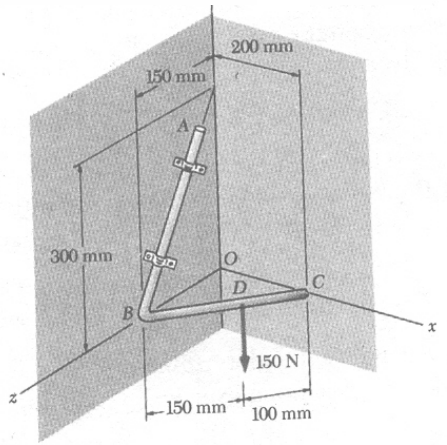
6. The rigid L – shaped member ABC is supported by a ball and socket at A and by three cables. Determine the tension in each cable and the reaction at A caused by the 2225N load applied at G.

Ans: T_{CF} *= 2.9 kN,* T_{BE} *= 2.9 kN,* T_{BD} *= 3.5 kN,*
A= -1.33i + 8.5j kN



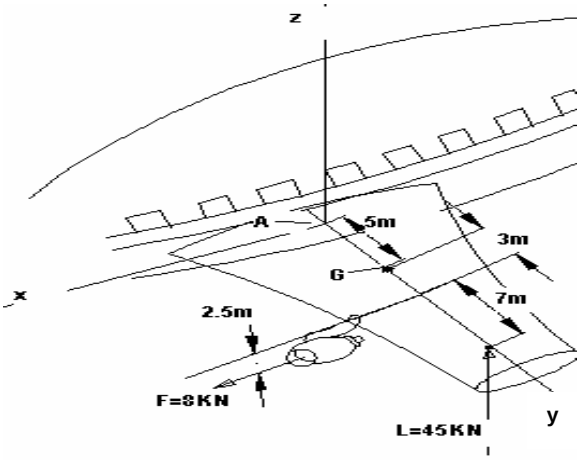
7. The bent rod ABC is hinged to a vertical wall by means of two brackets and bears at C against another vertical wall. Upper bracket fits in a groove in the rod to prevent the rod from sliding down. Neglecting friction, determine the reaction at C when a 150N load is applied at D as shown.

Ans: C= 45i kN



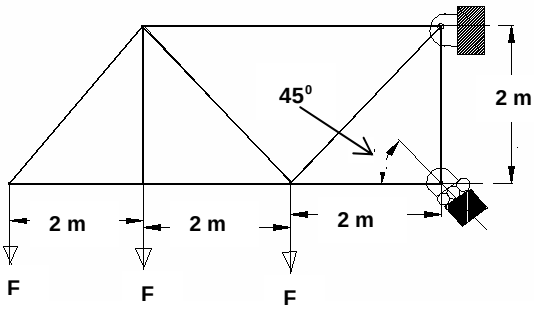
8. The wing of the jet aircraft is subjected to thrust of F = 8kN from its engine and the resultant lift force L = 45 kN. If the mass of the wing is 2100 kg. and the mass centre is at G, determine the x, y, z components of reaction where the wing is fixed to the fuselage at A.

Ans: M_A *= -572i + 20 j + 64 k kN m*

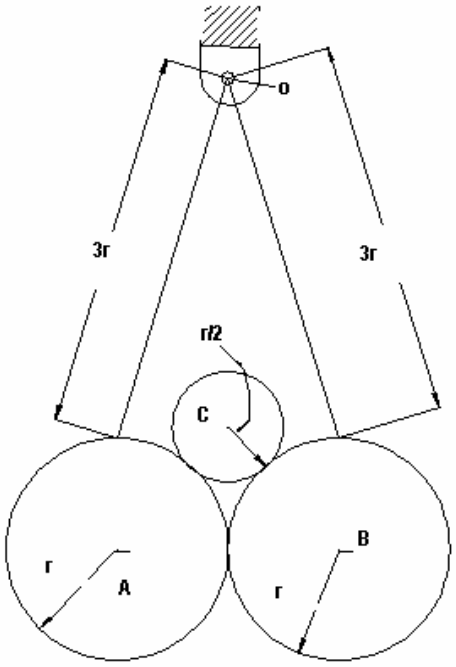


9. Consider the truss. If the roller at B can sustain a maximum load of 3KN, determine the largest magnitude of each of the three forces F that can be supported by the truss.

Ans: F=354 N



10. Two smooth tubes A and B, each having the same weight W, are suspended at their ends by cords of equal length. A third tube C is placed between A and B. Determine the greatest weight of C without upsetting equilibrium. *Ans:* W_C *=0.776 W*

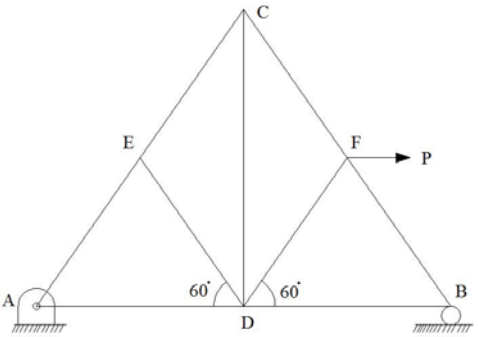


TRUSSES AND STRUCTURES

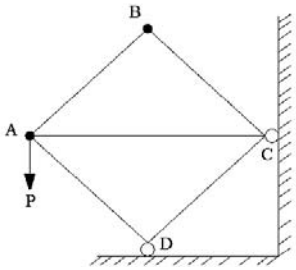
STRUCTURAL ANALYSIS

1. Determine the force in the bar CD of the simple truss supported and loaded as shown. The ABC forms an equilateral triangle.

Ans: BF= -0.5P,CF=0.5P,CD= -0.866P

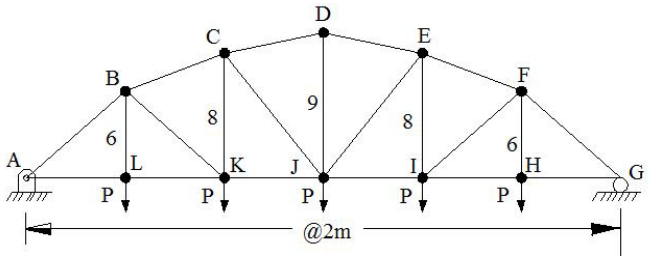


2. Determine the axial force in each bar of the plane truss supported and loaded as shown. Ans: DA=DC= - 0.707P, BC= -BA= 0.707P, CA=0



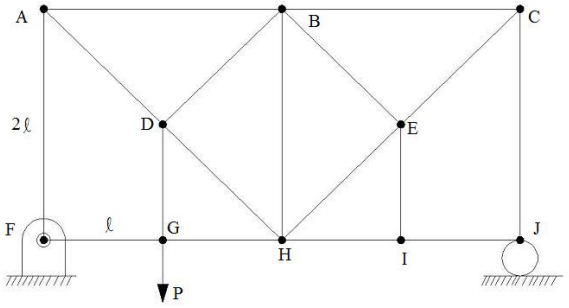
3. Roadway and vehicle loads are transmitted to the highway bridge truss as the idealized forces. What are the forces in members? Take P = 100KN.

Ans: AB=354kN, BK= -70.7 kN, JD=100 kN



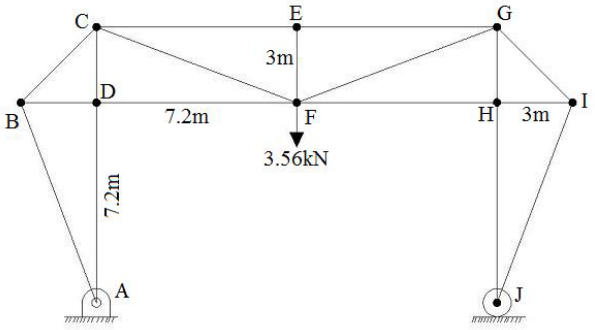
4. Indicate whether the truss shown is a simple truss. Determine the zero-force members for the given loading.

Ans: IE, JI, HI, BE, FG and GH



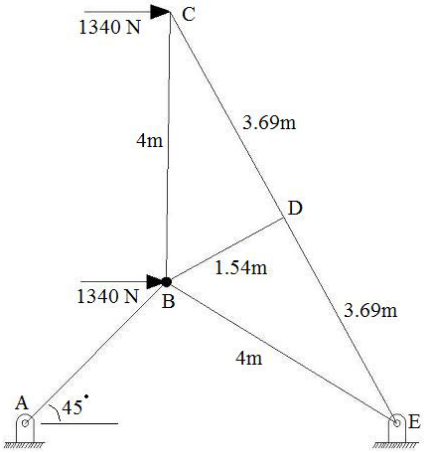
5. The trussed building bent is subjected to a loading of 3560N. Approximate each joint as a pin and determine the forces in each member. State whether the members are in tension or compression.

Ans: JH=AD=HG=CD=1780C,
GF,FC=4628 T,GE,EC=4272C

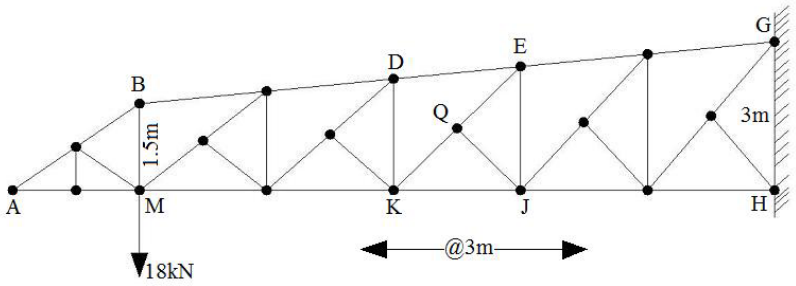


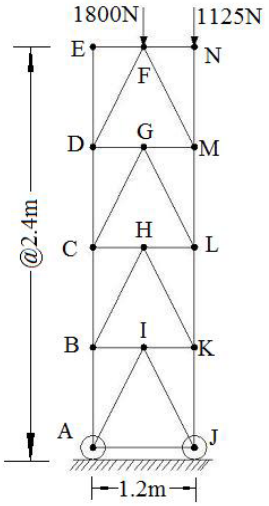
6. A sign is subjected to a wind loading that exerts horizontal forces of 1340N on joints B and C of one of the side supporting trusses. Determine the force in members BC, CD, DB and DE of the truss and state whether the members are in tension or compression.

Ans: CD=DE=3472C, BC=3202T, DB=0



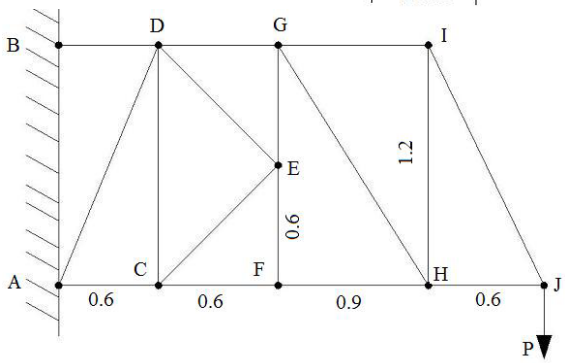
7. Determine the force developed in members DE, EQ and KJ of the side truss of the 'hammer-head crane'. Assume that each side truss supports a load of 18000N as shown. Indicate whether the members are in tension or compression. *Ans: QE=20.6kNT, DE=51.7kNT, KJ=67.5kNC*



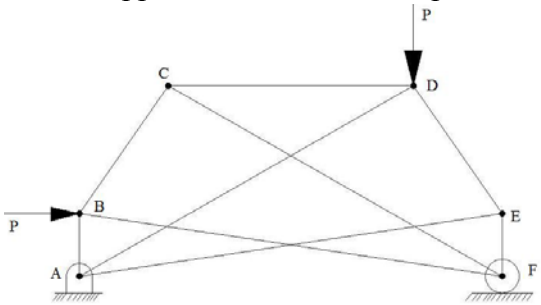


8. A "K" truss used for scaffolding is loaded as shown. Determine the force in members ML and CD using the method of sections. All joints are pin connected.
Ans: ML=2025N C, DC=900N C

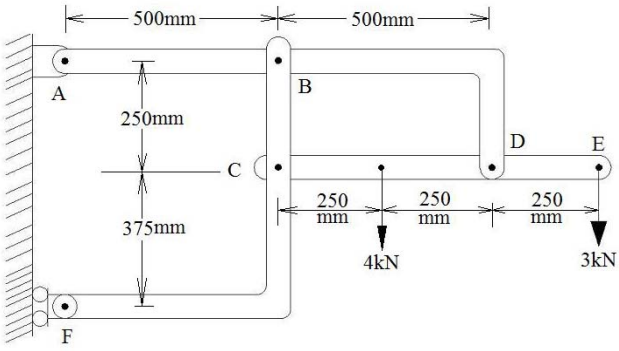
9. Determine by the method of sections the axial forces is each of the bars IH, GH and CF of the plane truss shown in the figure. *Ans: GH=2.92P C, IH=P T, CF=1.25P C*



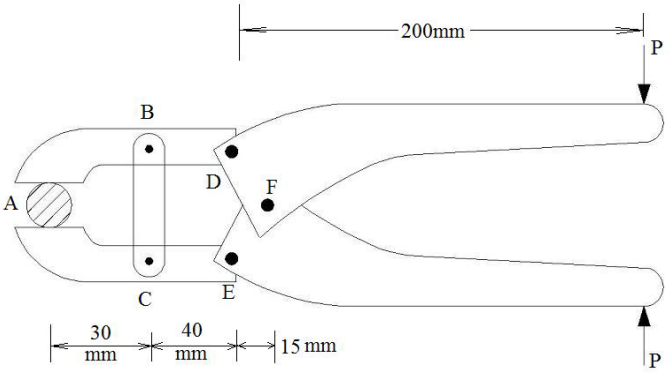
10. Determine the forces in the bars AB, CD, and EF of the plane truss loaded and supported as shown. The plane truss frame ABCDEF is one-half of a regular octagon. *Ans: AB= 0.293P, CD= -P, EF= -1.21P*



11. For the frame and loading shown, determine the components of all forces acting on member ABD.
Ans: A=-10.8i+7j kN, B= -16.2i-.5j kN, D=27i-6.5j kN



12. The tool shown is used to crimp terminals onto electric wires. Knowing that P= 135 N, determine the magnitude of the crimping forces which will be exerted on the terminal.
Ans: 2220 N



FRICTION

1. The co-efficient of friction are as follows: 0.25 at the floor, 0.30 at the wall, and a0.20 between blocks. Find the minimum value of force P applied to the lower block that will hold the system in equilibrium.

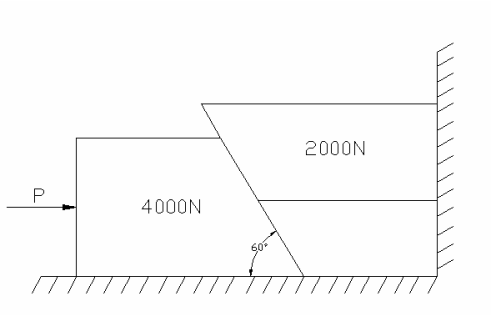


Fig 1

2. Two blocks connected by a horizontal link AB are supported on two rough planes as shown. The coefficient of friction for block A on the inclined plane is Ø=15^0 .What is the smallest weight W_A for which equilibrium of the system can exist?

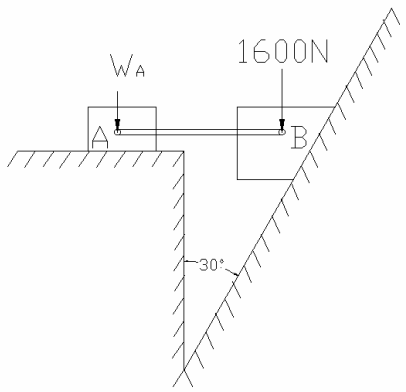


Fig 2

3. A car is stopped with its front wheels resting against a curb when its driver starts the engine and tries to drive over the curb. If the radius of the wheels is 280 mm, μ=.85 between the tyres and the pavement, and 60% of the weight of the car is distributed over its front wheels and 40% over its rear wheels, determine the largest curb height h that car can negotiate, assuming (a) front-wheel drive, (b) rear wheel drive.

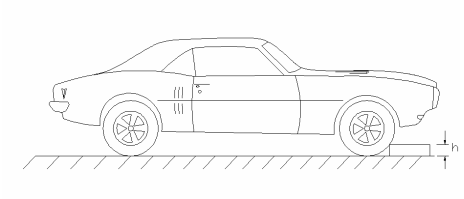


Fig 3

4. A shear shown is used to cut and trim electronic-circuit-board laminates. If μk=0.2 between the blade and the vertical guide, determine the force exerted by the edge E of the blade on the laminate.

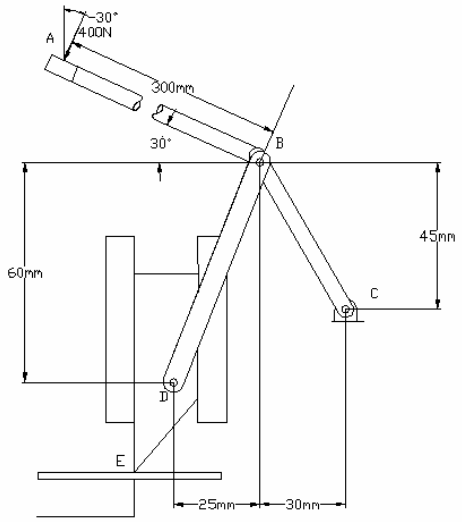


Fig 4

5.A slender rod of length L is lodged between peg C and the vertical wall and supports a load P at the end A. knowing that □=35^0 and that the coefficient of the static friction is 0.20 at both B and C,find the range of values of the ratio L/a for which equilibrium is maintained .

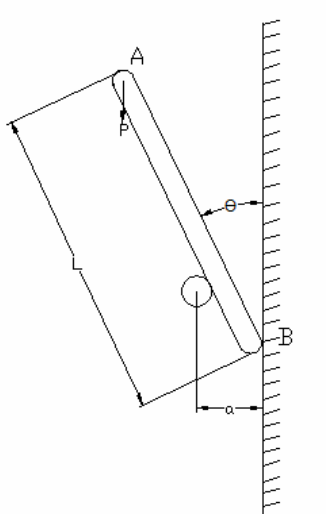


Fig 5

6. A 50 wedge is to be forced under a 6200N machine base at A. Knowing that μ=0.2 at all surfaces,(a) determine the force P required to move the wedge.(b) Indicate whether the machine will move.

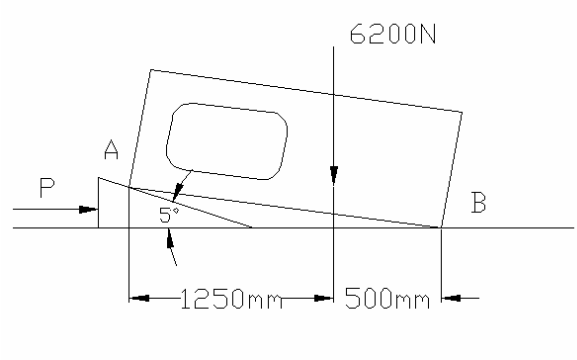


Fig 6

7. The beam AB has a negligible mass and is subjected to a force of 200N.It is supported at one end by a pin and at the other end by a spool having a mass of 35kg. If a cable is wrapped around the inner core of the spool, determine the minimum cable force P needed to move the spool from under the beam. μ_B=0.4 and μ_D=0.2

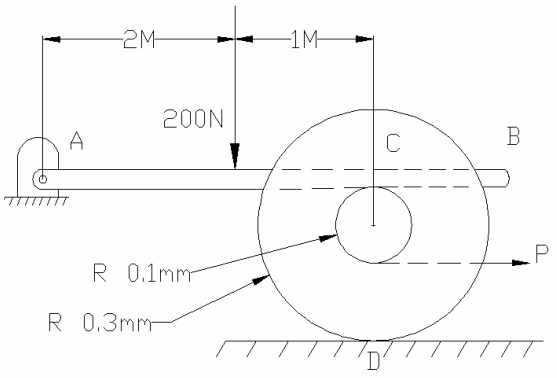


Fig 7

8. The breaking mechanism consists of two pined arms and a square threaded screw with left and right-hand threads. Thus, when turned, the screw draws two arms together. If the pitch of the screw is 4 mm, the mean diameter 12mm, and μ=0.35, determine the tension in the screw when a torque of 3N-M is applied to the screw. If the coefficient of friction between the brake pads A and B and the circular shaft is μ'=0.5. What is the maximum torque M the shaft can resists.

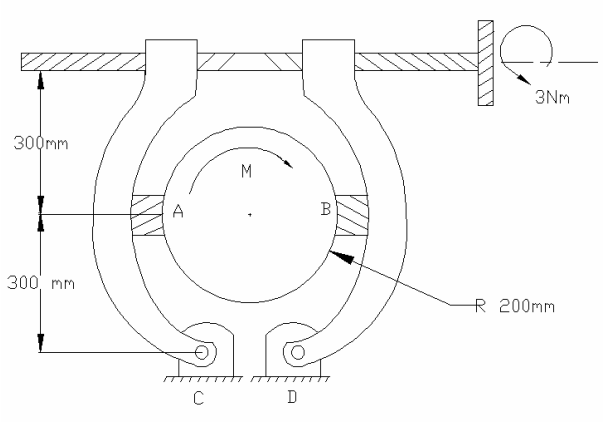


Fig 8

9. Two large cylinders each of radius r=500mm rotates in opposite directions and from the main elements of a crusher for stone aggregate. The distance d is set equal to the maximum desired size of the crushed aggregate. If d=20mm, μ_s =0.30, determine the sizes of the largest stones which will be pulled through the crusher by friction alone.

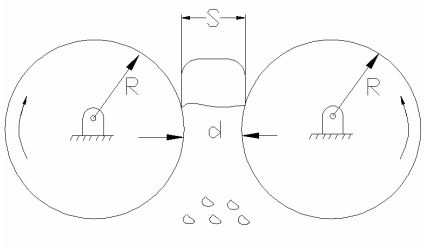


Fig 9

10. What is the maximum weight that can be supported by the system in the position shown? Pulley B can not turn. Bar AC is fixed to cylinder A, which weights 500N. The coefficient of static friction for all contact surfaces is 0.3.

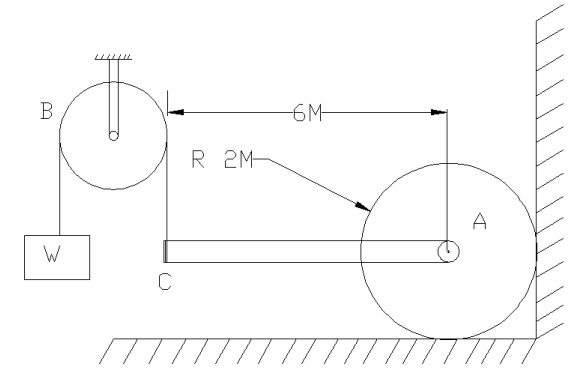


Fig 10

11. A freely turning idler pulley is used to increase the angle of wrap for the pulleys shown. if the tension in the slack side below is 900N,find the maximum torque that can be transmitted by the pulleys? Take μ=0.3

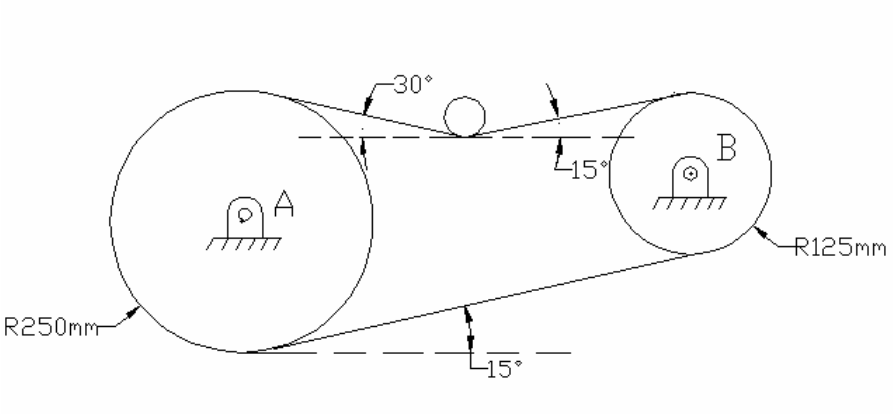


Fig 11

12. The truck, which has a mass of 3.4 tons, is to be lowered down the slope by a rope that is wrapped around a tree. If the wheels are free to roll and the rope at A can resist a pull of 500N.Determine the minimum numbers of turns the rope should be wrapped around the tree to lower the truck at constant speed. μ=0.4 between the tree and rope.

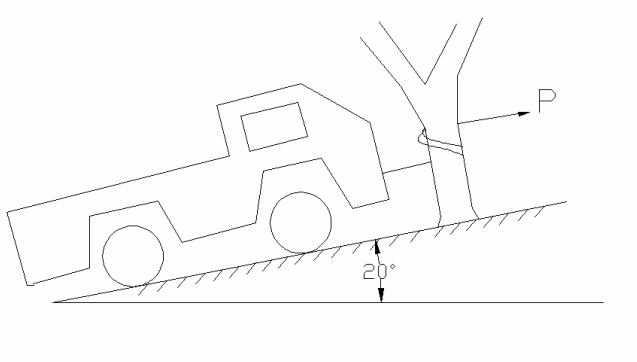


Fig 12

13. The 1.2 ton steel beam is moved over a level surface using a series of 30mm diameter rollers for which the coefficient of rolling resistance is 0.4mm at the ground and 0.2mm at the bottom surface of the beam. Determine the horizontal force P needed to push the beam forward at a constant speed.

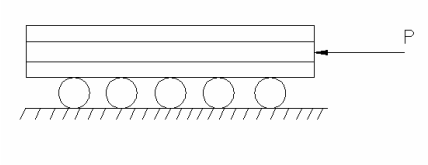


Fig 13

14. A cable is placed around three pipes, each of 15cm outside diameter, located in the same horizontal plane. Two of the pipes are fixed and do not rotate, the third pipe is rotated slowly. if μ_s=0.25 and μk=.02 for each

pipe, determine the largest weight W which can be raised (a) if only pipe A is rotated, (b) if only pipe B is rotated, (c) if only C is rotated.

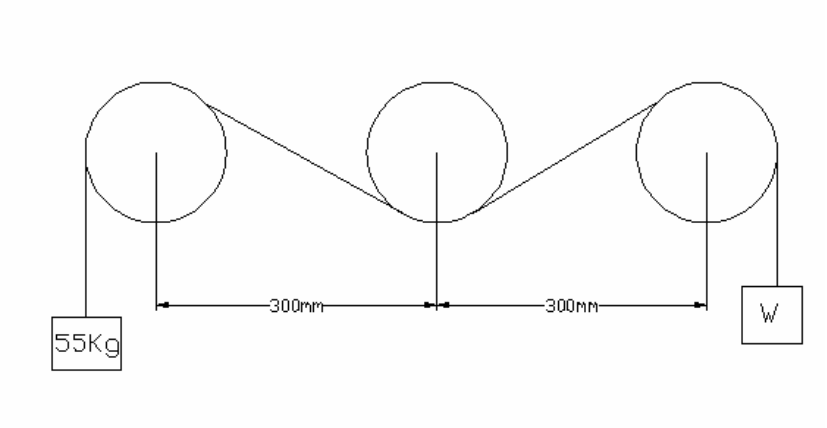


Fig 14

15. A 65 KN vehicle designed for polar expedition is on a very slippery ice surface with μ=0.005 between tires and ice. Coefficient of rolling friction is 0.8mm.will the vehicle be able to move? The vehicle has four wheel drive. If it has rear wheel drive only what is the minimum μ needed between tires and ground for it to move?

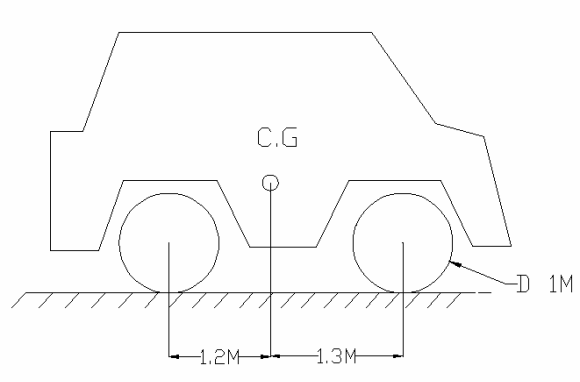
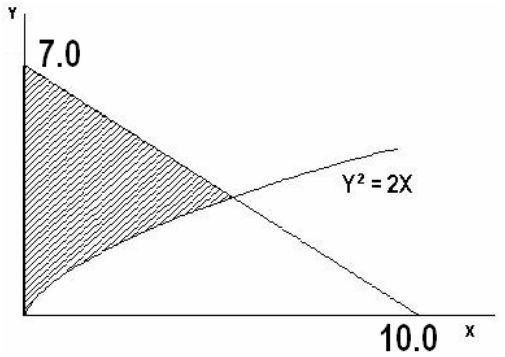
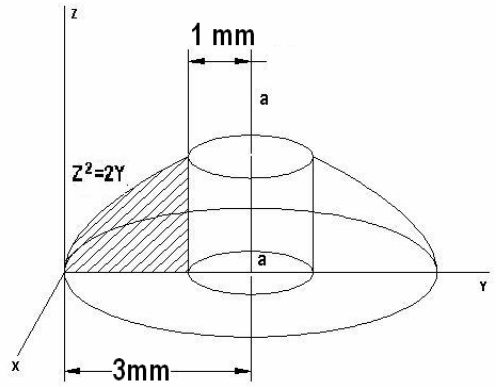


Fig 15

PROPERTIES OF SURFACES

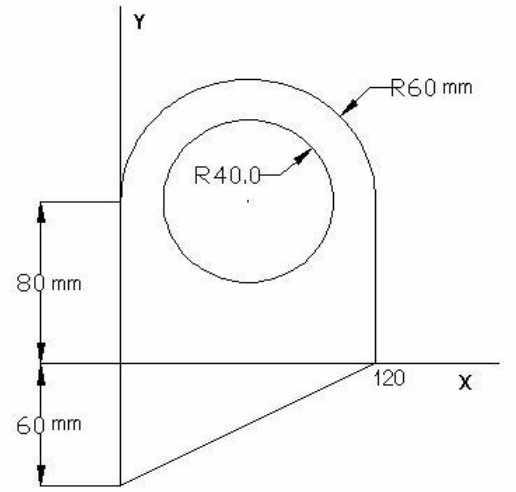
Q1: What are the coordinates of the centroid of the shaded area? The parabola is given as $Y^2=2X$. X & Y are in mm. (Ans: 1.7 mm, 3.75 mm)

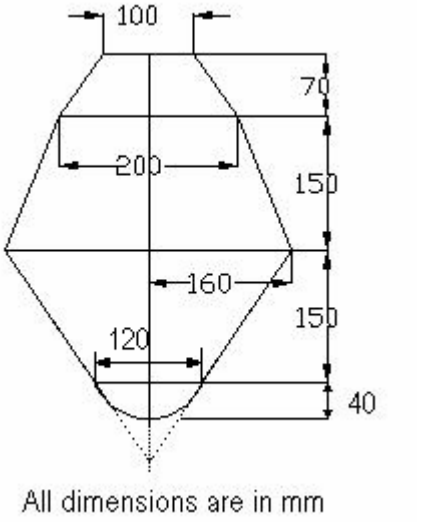




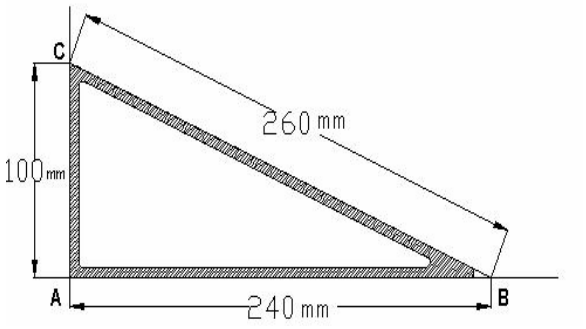
Q2: Locate the centroid of the volume formed by rotating the shaded area about the a-a axis. (Ans: 0.0m, 3.0m, 0.694m)

Q3: For the plane area shown, determine
(a) the first moments about X and Y axes, (b) the location of the centroid.
(Ans:$506x10^3 mm^3$, $758x10^3$ mm^3, 54.8mm, 36.6mm)



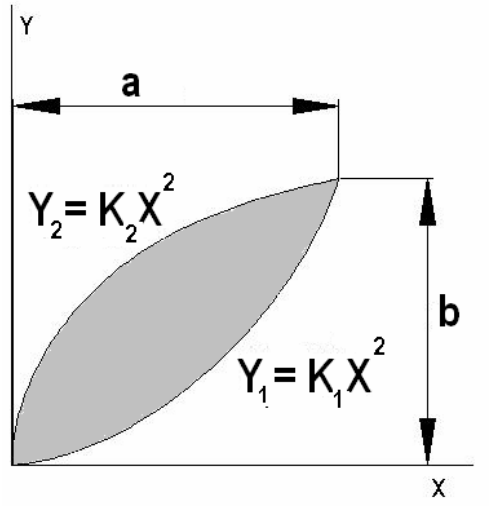


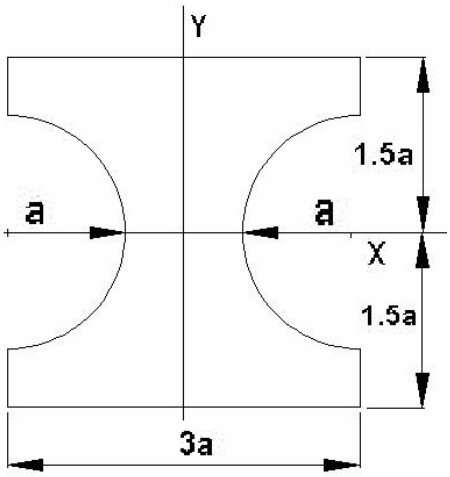
Q4: Find the surface area & earth entry capsule for an unmanned mars sampling mission. Approximate the rounded nose with a pointed nose as shown with dashed lines
(Ans: $0.862m^2$, $0.0633m^3$.)



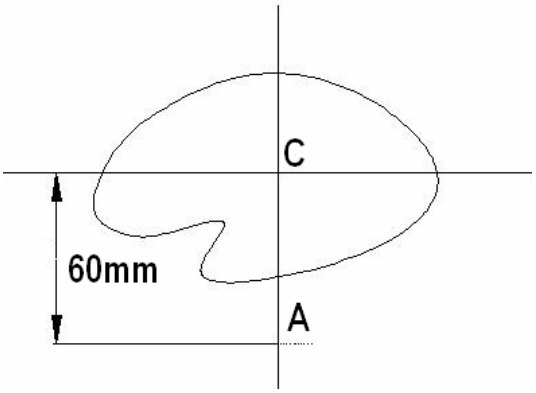
Q5: Determine the center of gravity of the triangular figure formed by bending a thin homogenous wire. (Ans: 100mm, 30mm)

Q6: Determine the moment of inertia and radius of gyration of the shaded area with respect to X & Y axes. (Ans: 3/35 ab^3, 3/35 a^3b, b√ (9/35), a√ (9/35))





Q7: Determine the moment of inertia of the shaded area shown with respect to the X & Y axes when a=20mm. (Ans: $95.4x10^4 mm^3$, $46.3x10^4 mm^3$)



Q8: The shaded area is equal to 5000 mm^2, determine the centroidal moment of inertia I_x & I_y knowing that $I_y=2I_x$ and the polar moment of inertia of the area about point A is $J_A = 22.5 \times 10^6 mm^4$. (Ans $1.5x10^6$ mm, $3.0x10^6$ mm)

Q9: Determine moment of inertia I_x ,I_y ,I_{xy} of the areas shown with respect to the centroidal X and Y axes. Also determine the orientation of the principal axes through the centroid and the principal moment of inertia.

Ans: (a) $3.2x10^6 mm^4$, $7.2x10^6 mm^4$, $2.4x10^6 mm^4$, θ=25.1°,$8.32x10^6 mm^4$, $2.1x10^6 mm^4$,
(b) $0.61x10^6 mm^4$,$1.9x10^6 mm^4$,$-0.8x10^6 mm^4$, θ=-25.7°,$2.28x10^6 mm^4$, $0.23x10^6 mm^4$,

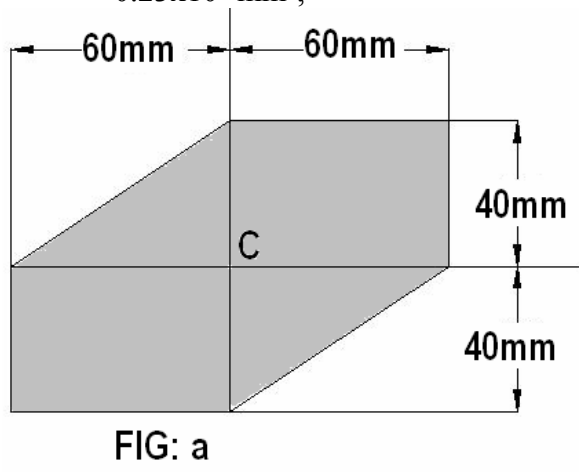


FIG: a

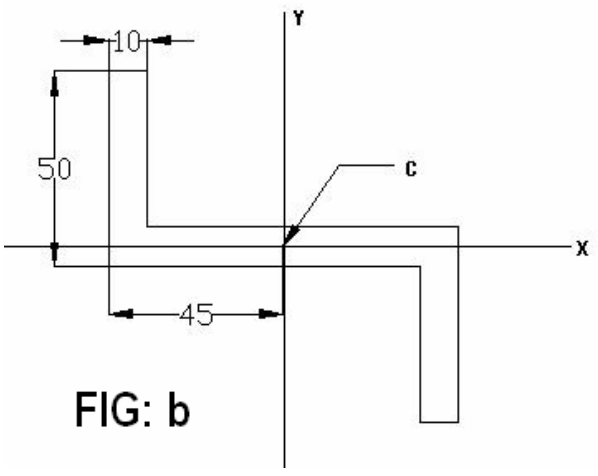


FIG: b