PUNE INSTITUTE OF COMPUTER TECHNOLOGY, PUNE-43

Engineering Mechanics

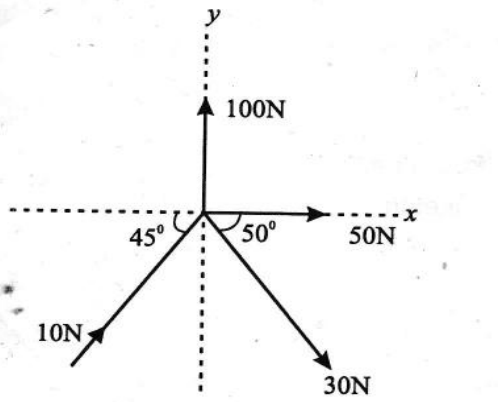
Question Bank

UNIT-1: RESOLUTION AND COMPOSITION OF FORCES

A) RESOLUTION OF FORCES

1.Resolve the forces along x and y directions.

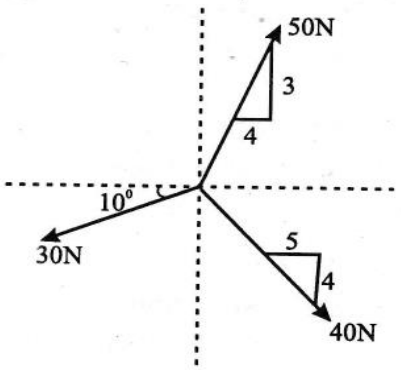
a)



Ans. $\Sigma F_x = 76.35N$
$\Sigma F_y = 84N$

Fig. 1a

b)

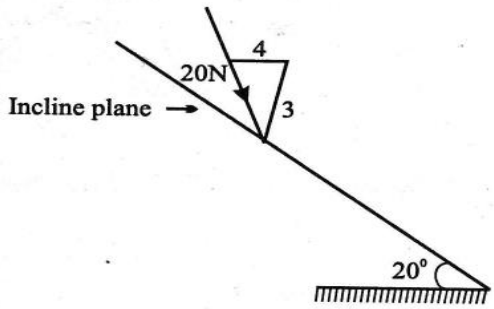


Ans. $\Sigma F_x = 41.69N$
$\Sigma F_y = -0.19N$

Fig. 1b

2. Resolve the force along incline plane and perpendicular to incline plane.

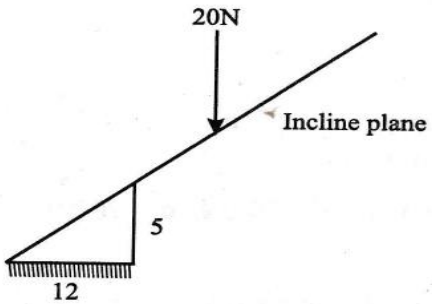
a)



Ans. $\Sigma F_x = 19.22N$
$\Sigma F_y = 8.54N$

Fig. 2a

b)



Ans. $\Sigma F_x = -7.6N$
$\Sigma F_y = 18.46N$

Fig. 2b

3 Resolve the force of 500 N in (Fig.3) into two components along lines OA and OB.

(Ans: P = 500 N, Q = 258.82 N)

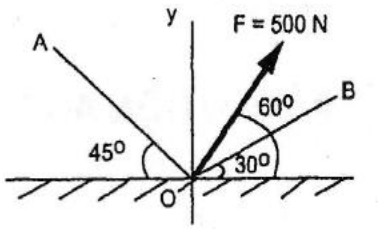


Fig. 3

4 At what maximum angle Θ should the force F be directed so that the magnitude of its component along CA does not exceed 80 percent of the magnitude of its component along BC? Refer Fig.4.

(Ans: Θ = 53°)

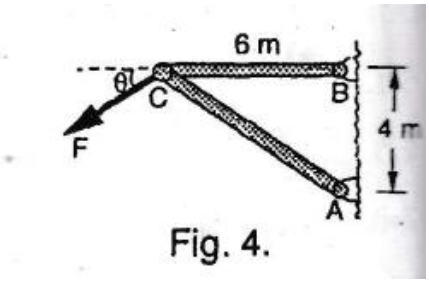


Fig. 4.

5 Resolve a force of 100N, into two components of 200 N each. Show the orientation of these components in a neat sketch.

(Ans: Θ = 151°, α = 75.5°)

6 A force R = 25 kN acting at O has three components P_A, P_B and P_c along the direction O_a, O_b and O_c respectively as shown in figure. The component P_c acts away from O is known to have a magnitude of 20 kN. Find the components P_A and P_B (Refer Fig. 6)

(Ans: P_A = 33.91 kN, P_B = 35.04 kN both away from O)

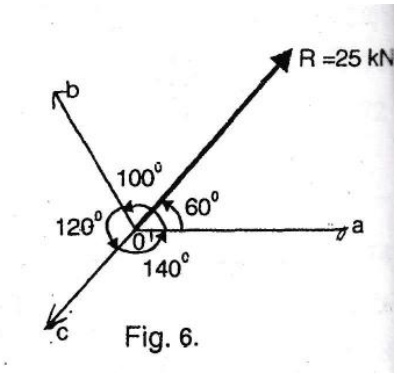


Fig. 6.

7 Find out resultant of following system of forces.

(R = 29.14 N)

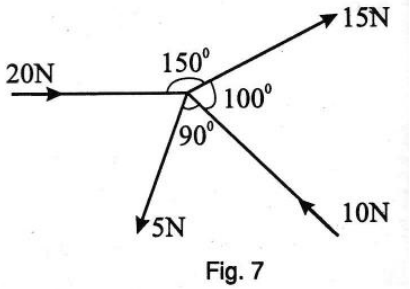


Fig. 7

8 Two forces 10N and 20N are acting at one point making an angle of 30°. Find out their resultant in magnitude and directions.

(Ans: R = 29.0N, α = 20.10°)

9 Two forces whose magnitudes are in the ratio 3:5 gives resultant of 35N. If the angle of Inclination between forces is 60°. Find out the magnitude of both the forces.

(Ans: 25 N, 15 N)

B) RESULTANT OF CONCURRENT COPLANER FORCE SYSTEMS

10 A boat is moved uniformly along a canal by two horses pulling with forces P = 1000 N and Q = 1200 N acting at an angle α = 60° (Fig.10). Determine the magnitude of the resultant pull on the boat and the angles β and γ.

(Ans. R = 1910 N, β = 33°, γ = 27°)

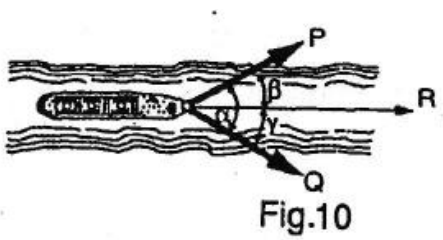


Fig.10

11 It is desired to remove the spike from the timber by applying force along its horizontal axis. An obstruction 'A' prevents direct access, so that two forces, one 1.6 kN and the other P, are applied by cables as shown in (Fig.11) Compute the magnitude of P necessary to ensure axial tension T along the spike. Also find T.

(Ans. P = 2.15kN, T = 3.20 kN.)

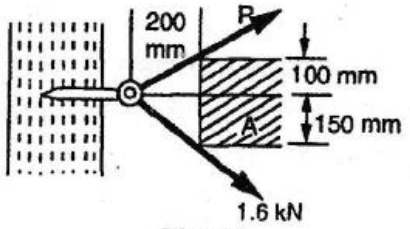


Fig.11

12 Find the resultant of the following force systems shown in Fig. 12.

(Ans: R = 64.758 kN, Θ = 2.824°, in IInd quadrant)

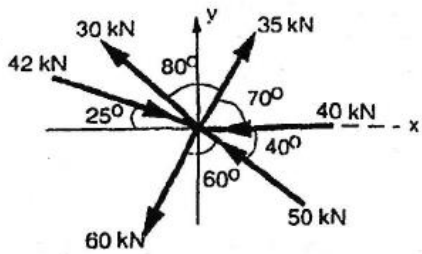


Fig.12

13 Forces 1, 2, 3, 4, 5, 6 N are acting from the center of regular Hexagon towards its angles taken into the order. Find out its resultant in the magnitude.

(Ans. 6 N)

14 A transmission cable AB exerts a 3500 N force on the pole in the direction of the tangent to the cable at A. Determine the required tension T in the guy wire AC if the resultant of the two forces at A is to be vertical. Find the magnitude R of the resultant. Refer (Fig.14)

(Ans: T = 4715.5 N, R = 5362 N)

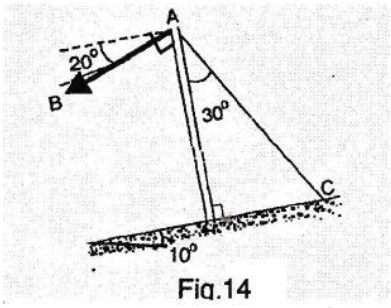


Fig.14

15 Three coplanar forces act at a point on a bracket as shown in (Fig.15). Determine the value of the angle α such that the resultant of the three forces will be vertical. Also find the magnitude of the resultant.

(Ans: α = 36.86° or -90°then R = 80 kN (↓) or R = 80 kN (↑))

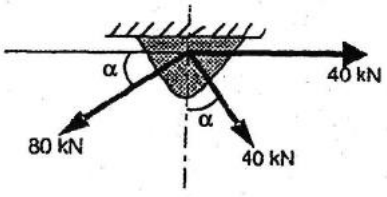


Fig.15

16 If the resultant of the force system in (Fig.16) is along the line AB, then find the magnitude of angle α, and the magnitude of the resultant force.

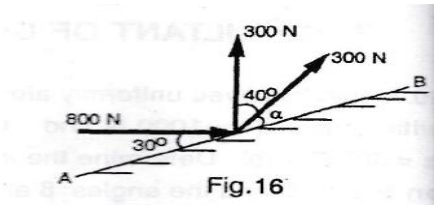


Fig.16

(Ans: α = 25.19°, R = 1090 N)

17 Determine the magnitude and direction of resultant with reference to point A for the force system as shown in Fig.17 if side of equilateral triangle is 1m.

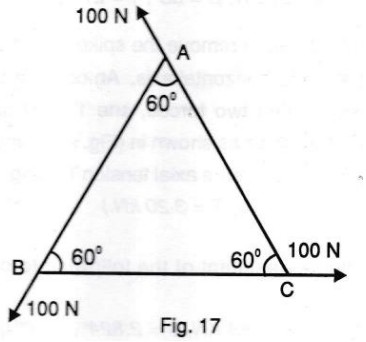


Fig. 17

(Ans: $\sum R = 0$ $\sum M = 86.6$ Nm)

18 Determine the required tension in cable AC, knowing that the resultant of the three forces exerted at point C of boom BC must be directed along BC. Also find the corresponding magnitude of the resultant. (Ref. Fig.18)

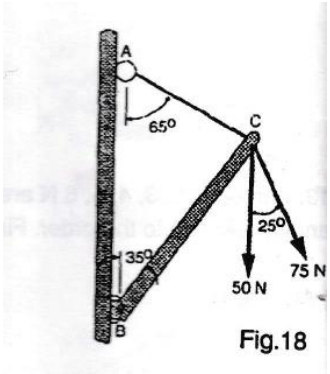


Fig.18

(Ans: T_{AC} = 95.07 N, R = 94.967 N)

C) FORCE COUPLE SYSTEMS / MOMENT OF FORCE

19 A force F of magnitude 40N is applied to the gear as shown in (Fig.19) Determine the moment of F about point 'O'.

(Ans: M_o = 3.76 N.m CW)

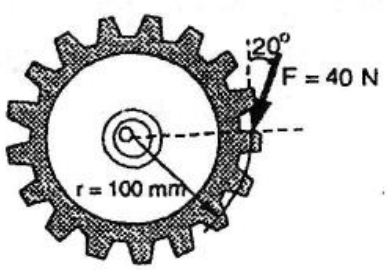


Fig. 19

20 The toggle switch is as shown in (Fig 20). Find the moment of 1.6 N force about pivot 'O'.

(Ans: M_o = 0.02941 N.m CCW)

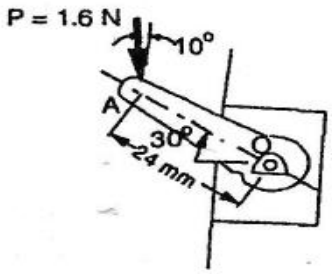


Fig. 20

21 Calculate the moment of the 250 N force on the handle of monkey wrench about the center of the bolt. Refer (Fig 21).

(Ans: M_o = 46.4 N.m CW)

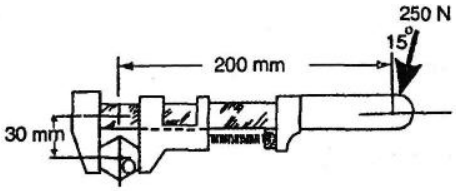


Fig. 21

22 Determine the angle Θ for which the moment at O reduces to 0. Refer (Fig 22).

(Ans: Θ = 20 °)

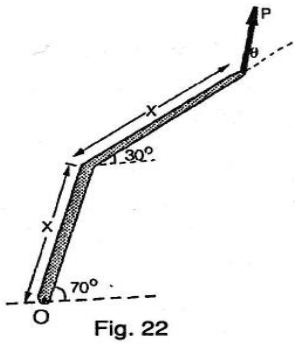


Fig. 22

23 Determine the angle Θ, which will maximize the moment M_O of the 200 N force about the shaft axis at O. Also compute M_O. Refer (Fig 23).

(Ans: Θ = 65.8 °, M_o = 59.2 Nm CW)

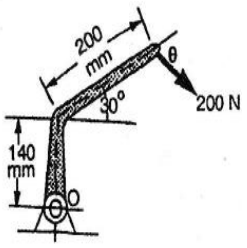


Fig. 23

24 In raising the flagpole from the position shown in (Fig 24) the tension 'T' in the cable must supply a moment about O of 72 kNm. Determine 'T'.

(Ans: 8.7 kN)

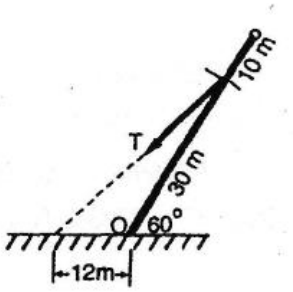


Fig. 24

25 The mast head fitting supports the two forces shown in (Fig 25). Determine the magnitude of 'T' which will cause no bending of the mast (zero moment) at point O.

(Ans: 3.229 kN)

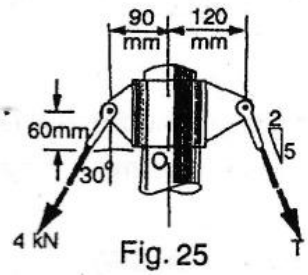


Fig. 25

26 Fig 26 shows points A, B and C lying in x-y plane. The moment of a certain Force 'F' acting in x-y plane is 180 N-m clockwise about the origin O, 90 N-m anti clockwise about Point B. if its moment @ point A is zero, determine the magnitude and direction of force 'F' and moment of force 'F' @ point C.

(Ans: F_x = 60N (→), F_y = 45N (↓), M_c = 120 Nm CCW)

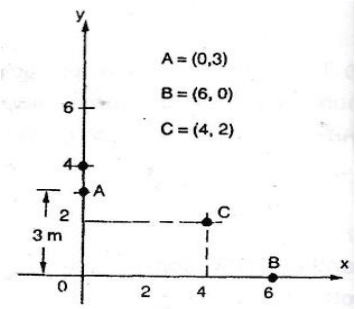


Fig. 26

27 The moments of a given plane system of forces about three points A = (0,1), B = (2,0) and C = (2,2) are M_A = +36, M_B = +3 and M_C = +21 units respectively. Find the magnitude and direction of the resultant force of the force system.

(Ans: 15N, Θ = 53.13°)

28 Replace the force and couple system shown in (Fig 28) by an equivalent single force and single moment at point P.

(Ans: R = 2.096 kN, Θ = 81.58°, M_P = 31.838 kN.m CCW)

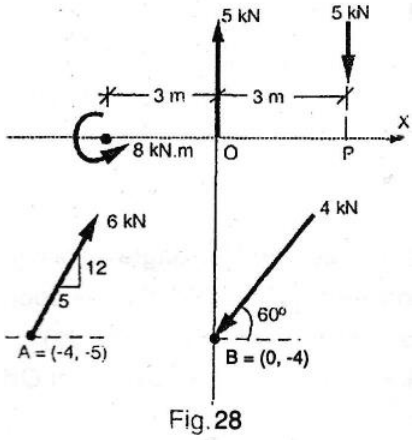


Fig. 28

29 If the combined moment of the two forces about C is zero, determine the magnitude R of the resultant, also find P. Refer (Fig 29)

(Ans: P = 3733.2 N, R = 2236 N, Θ = 26. 56° (second quadrant))

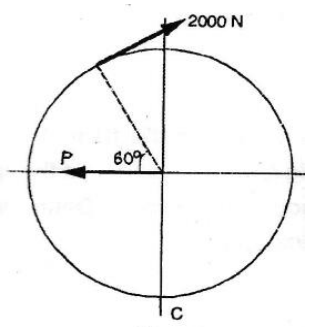


Fig. 29

30 The 37.5 Nm couple is applied to the vertical shaft, which is welded to the horizontal rectangular plate. If the couple and 300 N force are to be replaced by a single equivalent force at B, determine the distance 'x'. Refer (fig 30).

(Ans: x = 75 mm).

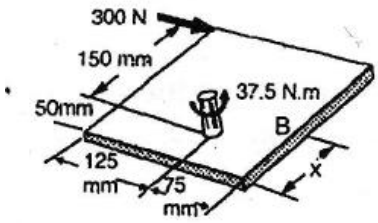


Fig. 30

31 A force of 800 N is acting as shown in (fig.31), resolve this force into parallel components P and Q acting along lines (a-a) and (b-b). Also resolve this force into parallel components P and Q along lines (b-b) and (c-c)

Ans: I) P = 480 N (↓), Q = 320 N (↓)
II) P = 400 N (↑), Q = 1200 N (↓)

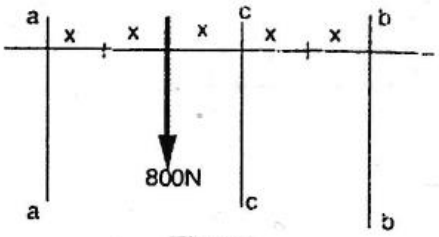


Fig. 31

32 Five forces are acting on regular hexagon as shown in (fig.32). A clockwise moment of magnitude 1 N.m is required to be applied at point A so that the rotation of the hexagon about A is prevented. Find the side of the hexagon.

(Ans. Side = 41.24 mm)

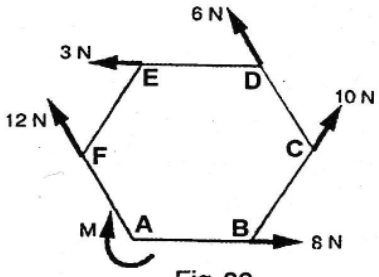


Fig. 32

33 Two parallel 60 N forces are applied to a lever as shown in (fig.33). Determine the moment of the couple formed by two forces (a) by resolving each force into horizontal and vertical components and adding the moments of the two resulting couples, (b) by using the perpendicular distance between the two forces

(Ans: For a, b, c, M = 12.39 N.m clockwise)

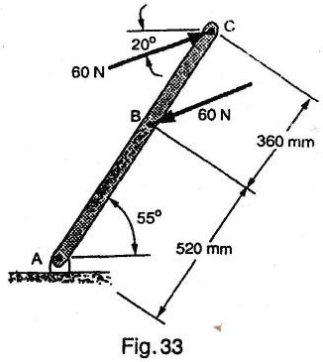


Fig. 33

D) RESULTANT OF PARALLEL COPLANAR FORCE SYSTEMS

34 Determine the resultant and its position of the three forces acting on pole AB. (Ref. Fig. 34)

(Ans: R = 50 N (→) 600 mm above B)

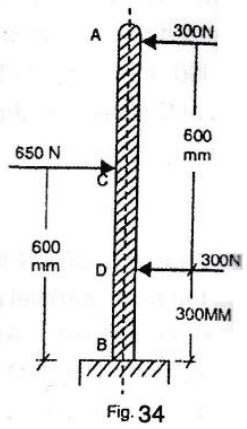


Fig. 34

35 Determine and locate the resultant 'R' of the two forces and one couple acting on the I-beam. (Ref. Fig. 35)

(Ans: R = 5kN (↓) at x = 4.6m)

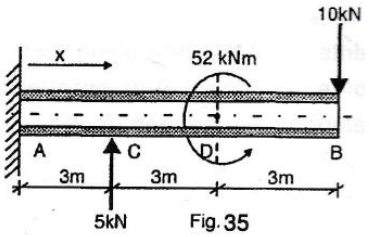


Fig. 35

36 A commercial airliner with four jet engines each producing 90 kN of forward thrust is in a steady level cruise when engine number three suddenly fails. Determine and locate the resultant of the three remaining engine thrust vectors. (Ref. Fig. 36)

(Ans: R = 270kN, 4m below the central axis)

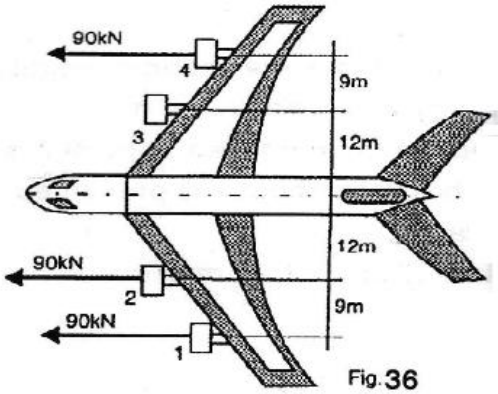


Fig. 36

37 A 4.8 m long beam is subjected to the forces as shown in figure. Reduce the given system of forces to a) an equivalent force – couple system at A. b) An equivalent force – couple system at B c) a single resultant force. (Ref. Fig. 37)

(Ans: a) R = 600 N (↓), M_A = + 1880 Nm
b) R = 600 N (↓), M_B = + 1000 Nm
c) R = 600 N (↓), x = 3.13 m to the right of A)

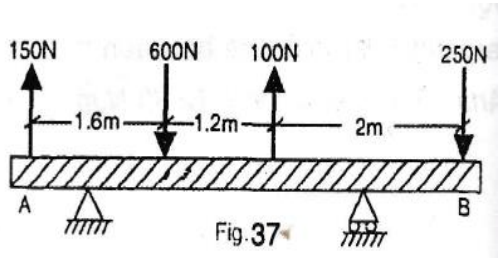


Fig. 37

38 The masses of two children sitting at ends A and B of a seesaw are 38 kg and 29 kg respectively. Determine where a third child should sit so that the resultant of the weight of the three children will pass through point C if she has a mass of a) 27 kg b) 24 kg. (Ref. Fig. 38)

[Ans: a) 0.66 m to the right of C
b) 0.743 m to the right of C]

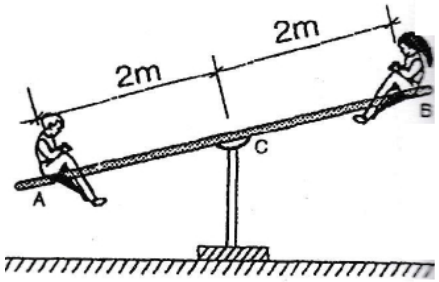


Fig. 38

39 Three hikers are shown crossing a footbridge. Knowing that the weights of the hikers at point C, D and E are 200 N, 175N and 135N respectively. Determine a) the horizontal distance from A to the line of action of the resultant of the three weights when a=3.3 m b) the value of 'a' so that the load on the bridge supports at A and B are equal. (Ref. Fig. 39)

[Ans: a) 7.82 m to the right of A
b) 4.478 m]

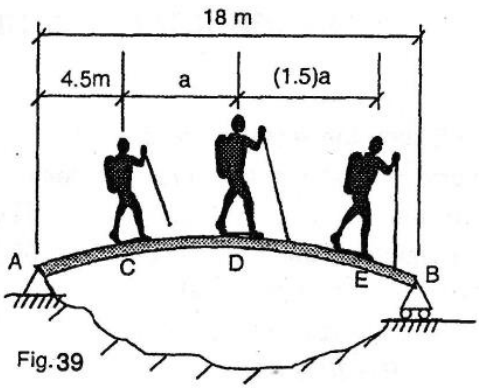


Fig. 39

40 By driving a truck over a scale, it was determined that the loads on the front and the rear axles are 18 kN and 12 kN respectively when the truck is empty. Determine the weight and the location of the heaviest load that the truck can carry if the load on each axle is not to exceed 40 kN. (Ref. Fig. 40)

(Ans: W = 30 kN, 3m to the right of the rear axles
50 kN, 2.2m to the right of the rear axles)

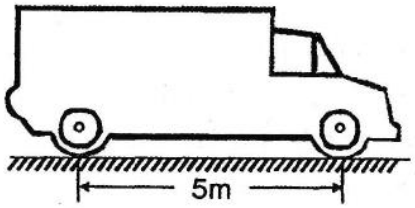


Fig. 40

E) RESULTANT OF THE GENERAL COPLANAR FORCE SYSTEM

41 Obtain the resultant of the four forces and a moment as shown in figure. Also locate the x co-ordinate and y co-ordinate of the points where the resultant cuts the co-ordinate axes. (Fig. 41)

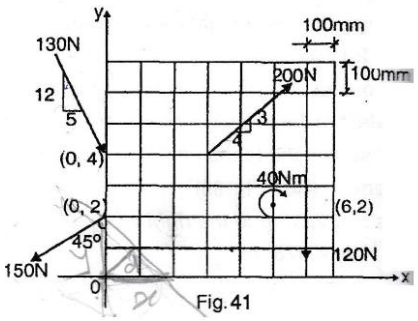
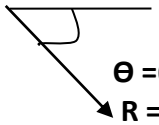


Fig. 41

[Ans: R_x = 103.95 N (→)
R_y = 226.05 N (↓)
P = (0, 9.89 m)
Q = (4.55 m, 0)]



Θ =65.29°
R = 248.78 N

42 Determine the resultant R of the three forces and two couples shown. Find the co-ordinate x of the point of the x axis through which R passes. (Fig. 42)

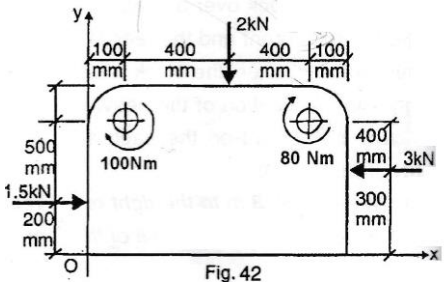
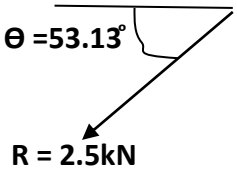


Fig. 42

(Ans:



Θ =53.13° P= (0.29m, 0)
R = 2.5kN

43 A machine component is subjected to the forces and couples as shown in the Fig. 43. The component is to be held in place by a single rivet that can resist a force but not a couple. For P = 0, determine the location of the rivet hole if it is to be located a) online FG, b) online GH.

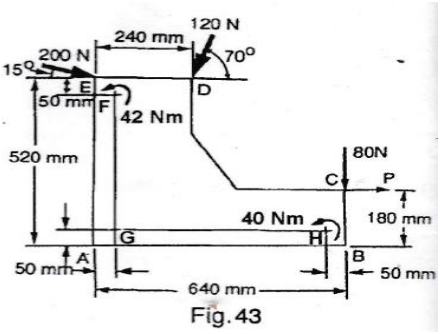


Fig. 43

(Ans: a) 365mm above G
b) 227mm to the right of G)

44 Determine the magnitude of the moment of the couple 'M_A' if the line of action of the resultant of this force system in (Fig. 44) is to pass through point B and point C.

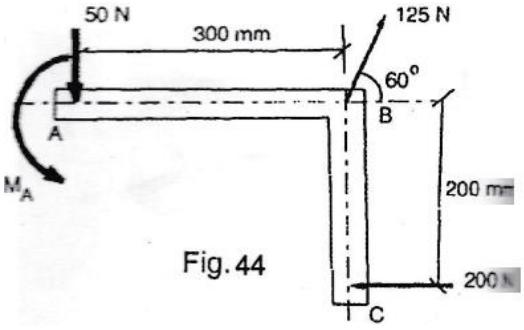


Fig. 44

(Ans. (i) M_A = 25N.m CCW, (ii) M_A = 2.5N.m CW)

45 The lever ABC fixed at A shown in Figure is subjected to a 200 N force at C at Θ = 30°, Find the moment of this force about A. Also find the value of Θ for which the moment about A is Zero.

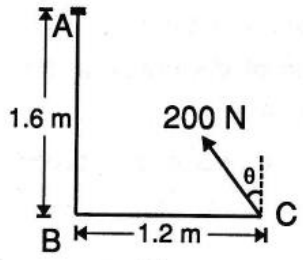


Fig. 45

(Ans: M_A = 47.85N.m, Θ = 36.87 °)

46 A hexagonal plate is acted upon by the force P and the couple shown in (Fig. 46). Determine the magnitude and the direction of the smallest force P for which this system can be replaced with a single force at E.

(Ans: P_{min} = 300N, α = 30°)

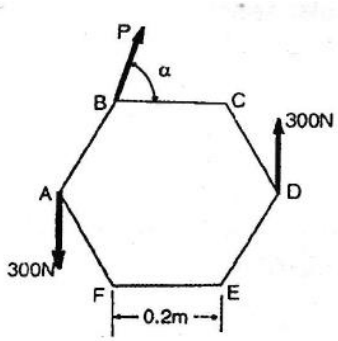
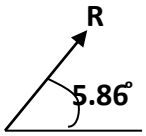


Fig. 46

47 Replace the three forces and couple shown in R (Fig. 47) by an equivalent force R at A and a couple M. Specify M and the magnitude of R.

(Ans. M = 16.28 kN.m CW, R = 12.23 kN.)



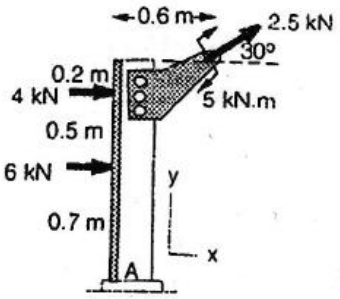


Fig. 47

48 Find the equilibrant of the coplanar system of four forces acting on the plate as shown in (Fig. 48)

(Ans: 150 Nm)

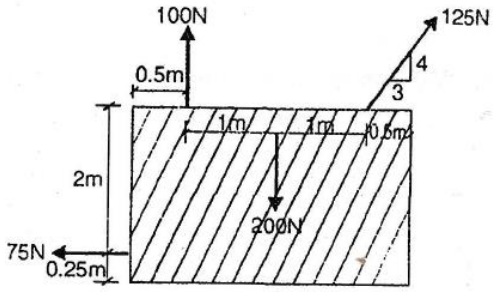


Fig. 48

****