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Mechanics

Chapter 1: Resolution of Forces

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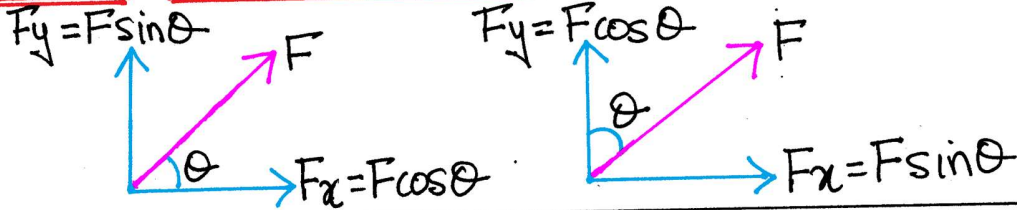
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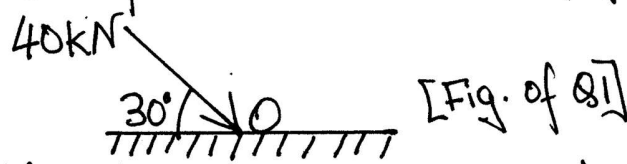
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CHAPTER 1: RESOLUTION OF FORCES

TYPE I: RESOLVING A FORCE: -



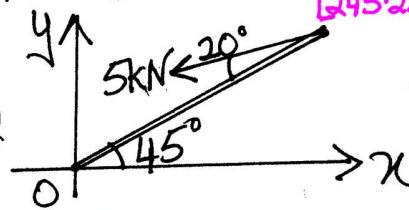
Q1) Resolve the force shown in figure



[34.64kN
20kN]

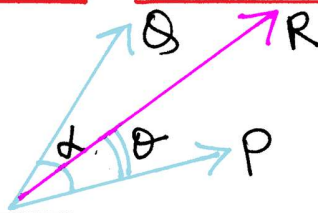
Q2) A block of weight 50kg is placed on an inclined surface making 30° with the horizontal. Resolve weight into its components along the surface and perpendicular to the surface.

Q3) Resolve following force: along x and y axis



[4.53kN
2.11kN]

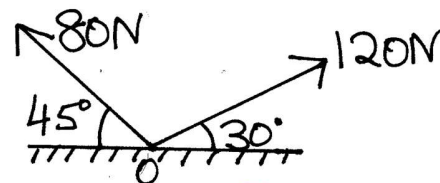
TYPE II: RESULTANT OF TWO FORCES (PARALLELOGRAM LAW OF FORCES)



$$R = \sqrt{P^2 + Q^2 + 2PQ \cos \alpha}$$

$$\tan \theta = \frac{Q \sin \alpha}{P + Q \cos \alpha}$$

Q4) Find the resultant of:-



[125.82N, 37.89]

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Q5) Find forces P and Q such that if they are perpendicular to each other then the resultant is $\sqrt{34}$ N and if they make 60° with each other then the resultant is 7N [5N/3N or 3N/5N]

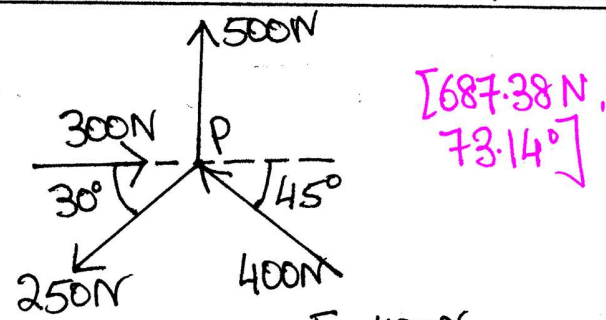
TYPE III:- RESULTANT OF TWO OR MORE FORCES:-

$$R = \sqrt{(\sum F_x)^2 + (\sum F_y)^2}$$

$$\tan \theta = \frac{|\sum F_y|}{|\sum F_x|}$$

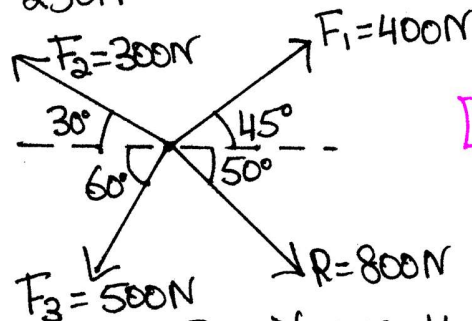
Quadrant	$\sum F_x$	$\sum F_y$
I	+ve	+ve
II	-ve	+ve
III	-ve	-ve
IV	+ve	-ve

Q6) Calculate the resultant force of:-



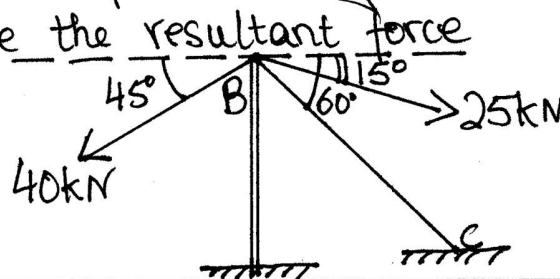
[687.38 N, 73.14°]

Q7) If resultant of four concurrent forces is 800N. Calculate the fourth force



[961.63 N, 39.58°]

Q8) Calculate force in cable BC if resultant of three concurrent forces acting at B is vertical. Also calculate the resultant force



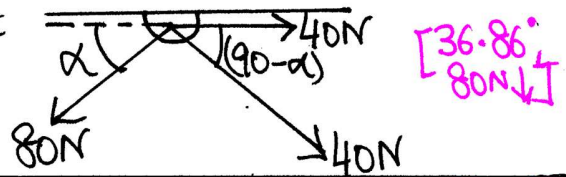
[8.27 kN, 41.92 kN]



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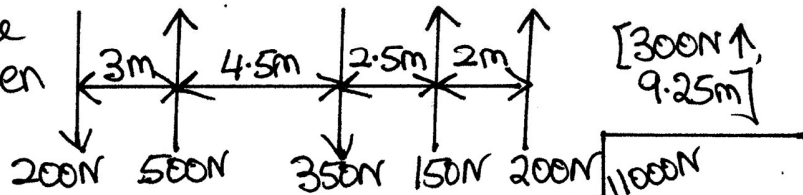
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Q9) Calculate α if resultant of 3 forces is vertical. Also calculate resultant force.

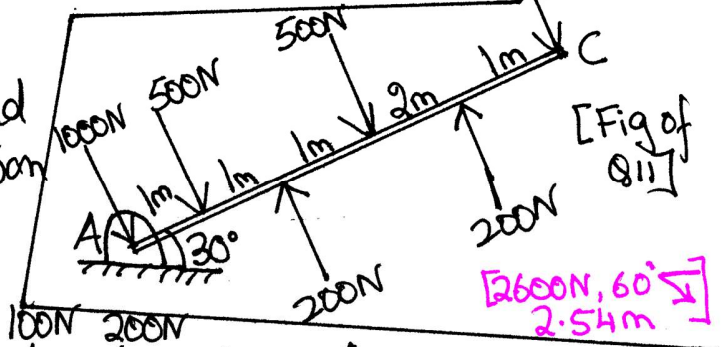


TYPE IV:- RESULTANT OF PARALLEL FORCES:- $[\sum M_A^F = M_A^R]$

Q10) Calculate the resultant of given forces :-



Q11) For forces acting on roof truss AC, find resultant & its location w.r.t. hinge A.



Q12) Find resultant of parallel forces:-



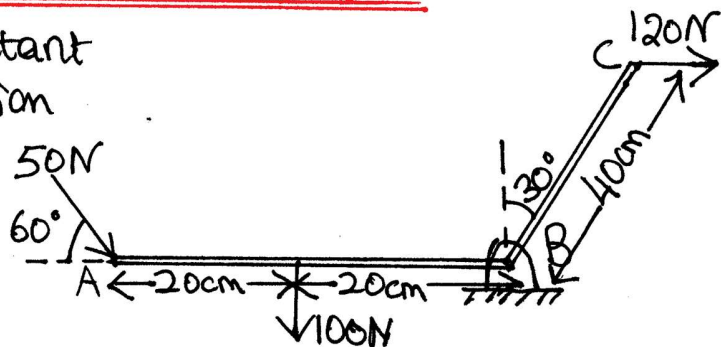
Q13) $\begin{matrix} 200N & 300N & 150N & 50N \\ \uparrow & \uparrow & \uparrow & \downarrow \\ A & B & C & D \end{matrix}$
Distances: A-B = 2m, B-C = 1.5m, C-D = 3.5m

(a) Calculate resultant and its location from point A
(b) Replace the system by a single force and a couple acting at point (i) B (ii) D
Handwritten note: $[200N \uparrow, 3.875m, 375Nm \uparrow, 625Nm \downarrow]$

TYPE V:- GENERAL FORCE SYSTEM:-

Q14) Find the resultant force and its location from hinge B

Handwritten note: $[203.86N, 44.66, 2.08cm]$



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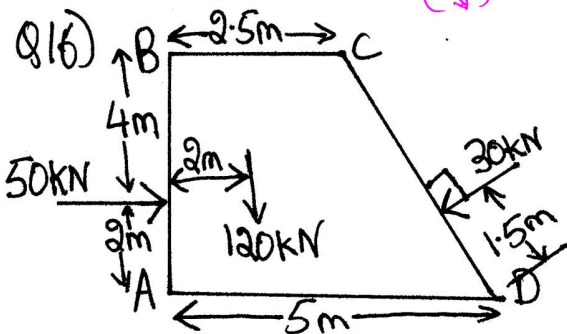
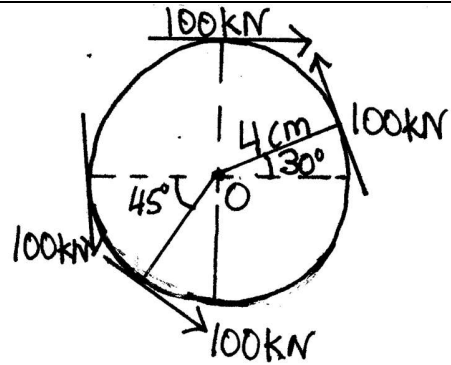


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Q15) Four tangential forces act on a circle of radius 4cm. Calculate resultant & its location w.r.t. centre of the circle

$[147.12\text{N}, 34.87^\circ, 5.44\text{m}]$

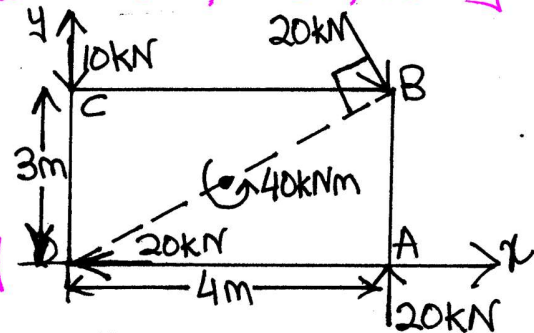


A dam is acted on forces as shown in figure. Find a single force and locate its point of intersection with base AD.

$[133.42\text{kN}, 80.37^\circ, 2.68\text{m}]$

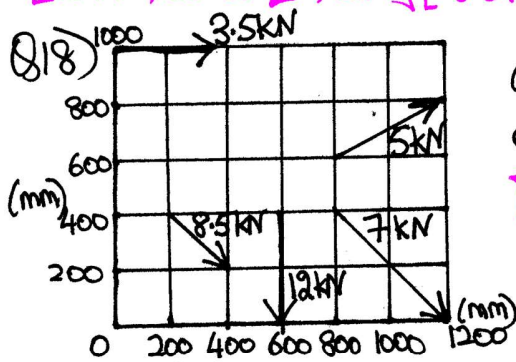
Q17) Find the resultant of given system, locate its distance from O. Also find where it cuts x and y axis

$[10\text{kN}, 36.86^\circ, 2\text{m}] [-3.34\text{m}, 2.5\text{m}]$



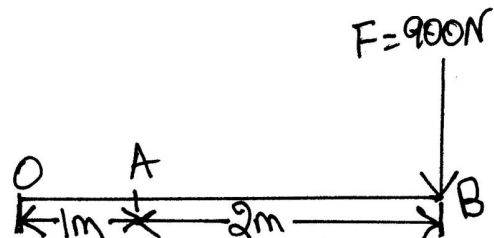
Calculate the resultant force and its location from O.

$[28.07\text{kN}, 47.59^\circ, 753.12\text{mm}]$



TYPE VI

Q19) Resolve the force 'F' of 900N acting at B into
(i) Parallel component at 'O' & 'A'
(ii) A couple and force at 'O'



$[F_A = 2700\text{N}(\downarrow), F_O = 1800\text{N}(\uparrow), M_O = 2700\text{Nm}(\curvearrowright), F_B = 900\text{N}(\downarrow)]$

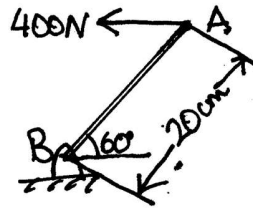
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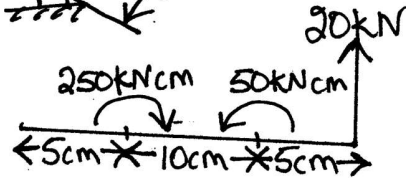
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Q20) Replace 400N at point B and a couple
[400N (←), 69.28 Ncm (↻)]

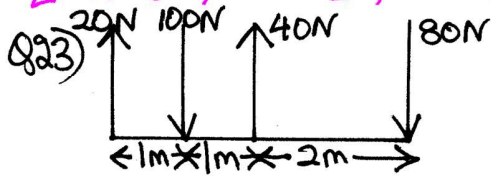
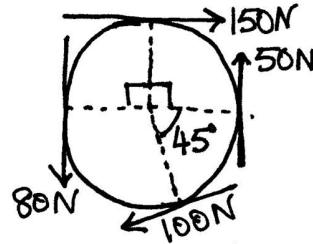


Q21) Replace force system acting on a bar by a single force
[20kN (↑) at midpt.]



Q22) Calculate the resultant of four forces and its location if radius = 3m

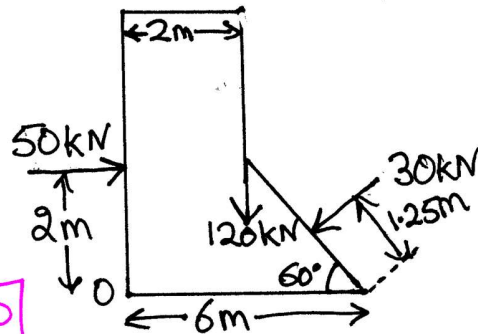
[128.18 N, 57.77° ↘, 2.81m]



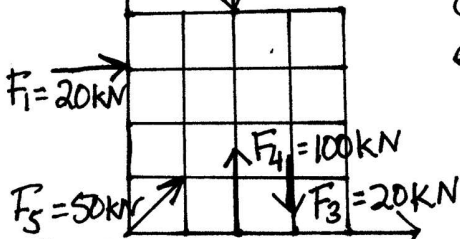
Calculate the resultant force and its location
[120N (↓), 2.83m]

Q24) The forces are acting on 1m length of dam. Calculate resultant force and point of intersection of the resultant with base.

[137.12kN, 79.91° ↘, 2.91m from O]



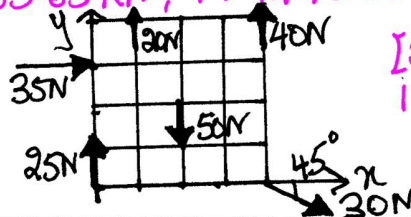
Q25) $F_1 = 20kN$, $F_2 = 50kN$, $F_3 = 20kN$, $F_4 = 100kN$, $F_5 = 50kN$



Calculate resultant force and its location from O if side of each small square is 1m & overall size is 4m x 4m

[85.65kN, 49.74°, 0.23m]

Q26) Calculate resultant force & its location for 1m x 1m small squares



[57.88N, 13.78° ↗, 1.9m]

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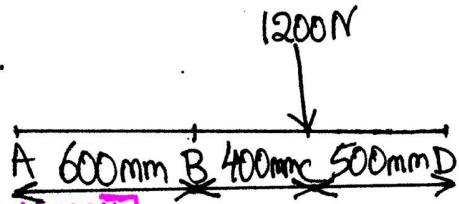


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Q27) i) Resolve 1200N at C into parallel components at A and B.

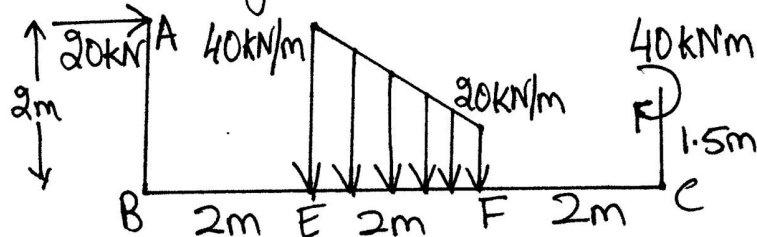
(ii) Replace 1200N at C by a force couple system at D



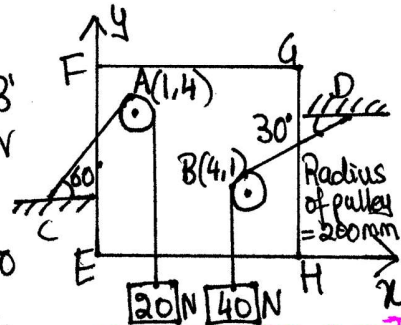
[800N(↑), 200N(↓), 600Nm(⋄), 1200N]

[B 25kN, 71.57°, 4.22m]

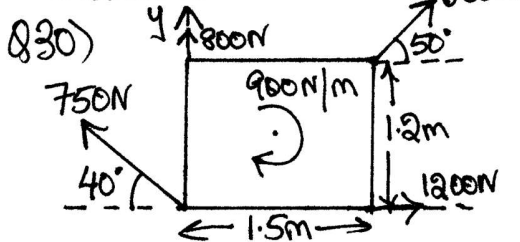
Q28) Find position and magnitude of resultant.



Q29) A square board EFAG is fixed in a vertical plane. Two pulleys 'A' & 'B' on the board carry loads of 20N & 40N suspended by strings. Find (i) Resultant of forces transmitted by two pulleys to the board (ii) 'x' & 'y' intercepts of the resultant.



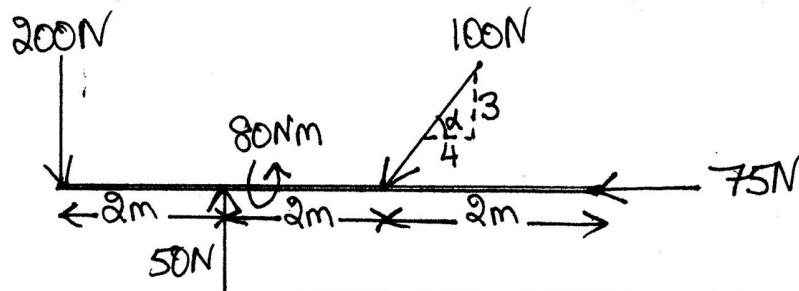
[62.39N, 66.74°, 1.95m, 4.54m]



Find the resultant of force system acting on a body. Also find the points where the resultant cuts 'x' & 'y' axes.

[2013.9N, 59.86°, 0.39m, 0.67m]

Q31) Replace the system of forces and couple by a single force couple system at A



[261N, 53.57°, 60Nm]

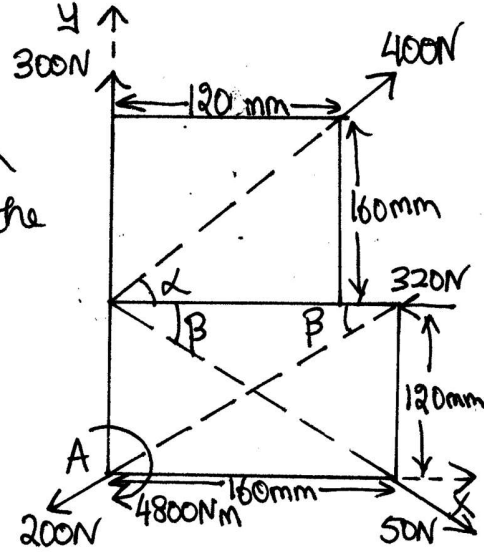
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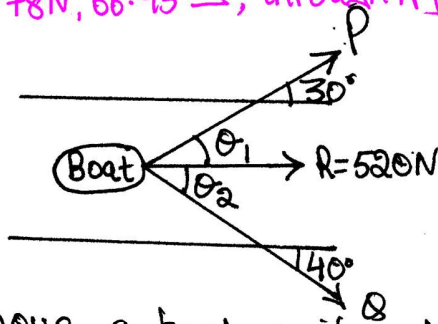
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Q32) Find the resultant of the coplanar force system. locate the position of the resultant on AB with due consideration to the applied moment



[510.78N, 66.95°, through A]

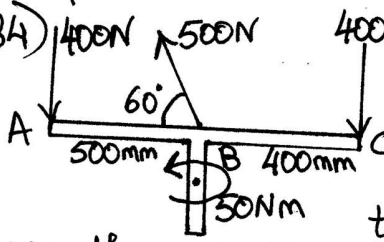
Q33)



To move a boat uniformly along the river at a given speed a resultant force $R = 520\text{N}$ is required. Two men pulling with forces P & Q by means of ropes do this. The ropes makes an angle of 30° & 40° respectively with the sides of the river. (a) Determine the forces P & Q (b) If $\theta_1 = 30^\circ$ find value of θ_2 such that the force in rope Q is minimum. What is this minimum force Q .

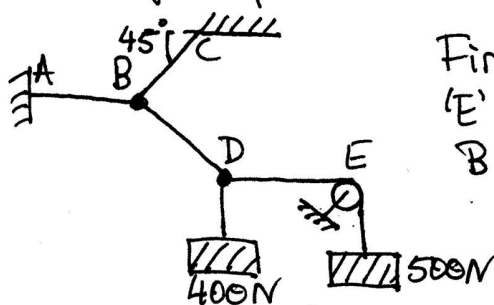
[FIG OF Q32]
355.09N, 277.41N, $\theta = 60^\circ$, $Q = 260\text{N}$

Q34) A bracket is subjected to a coplanar force system. Determine the magnitude & line of action from A of the single resultant of the system. If the resultant is to pass through the point B, what should be the magnitude & direction of couple



444.05N, 55.74°, 323.03, 90.19mm, $M = 40048.87\text{Nmm}$ (5)

Q35)



Find force in cable BC if 'E' is a frictionless pulley & B & D are weightless rings.

565.41N

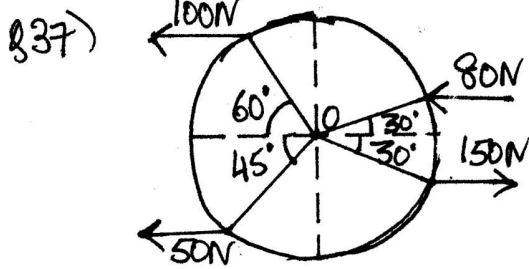
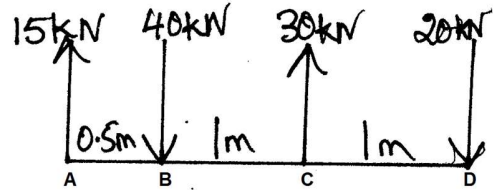
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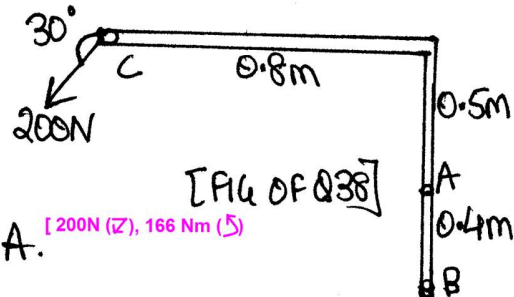
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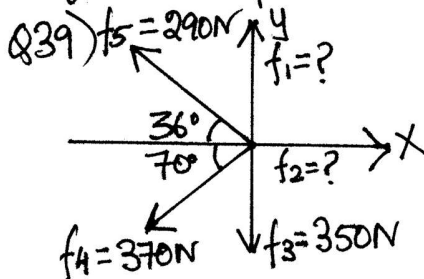
Q36) Replace force system by two parallel forces at B and D.
[15kN(↓), 1.67m, 6.25kN(↓), 8.75kN(↓)]



Determine resultant of the following parallel forces
[80N(←), 2.08R]

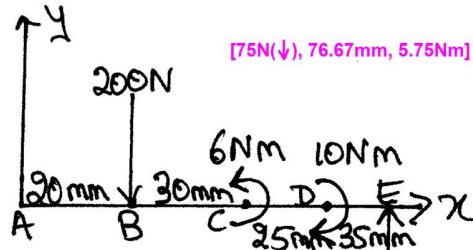


Q38) If the force of 200N is acting on the bracket find the equivalent force and couple at A.
[200N(Z), 166 Nm(S)]

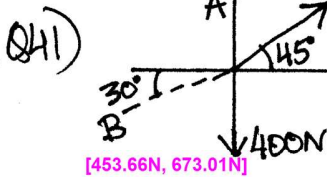


Determine magnitude and the direction of force f_1 and f_2 , when the resultant of given force system is found to be 800N along the x' axis
[527.23N, 1161.16N]

Q40) Replace the system of forces and couples by a single force & couple at A



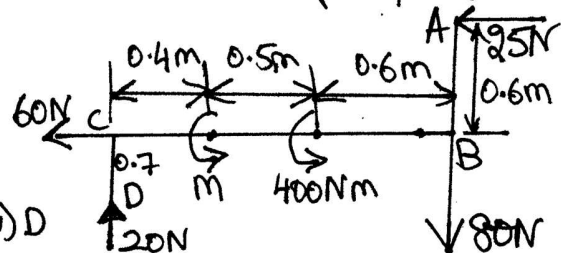
[75N(↓), 76.67mm, 5.75Nm]



[453.66N, 673.01N]

Three concurrent coplanar forces act on a body at point O. Determine two additional forces along OA & OB such that the resultant of 5 forces is 0

Q42) A bracket subjected to forces and couples as shown in figure. Find value of M and its direction if resultant is to pass through (i) Pt. A (ii) B (iii) C (iv) D
[-334, -385, -295, -354.5]

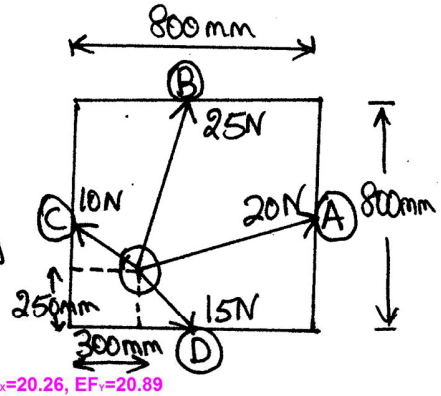


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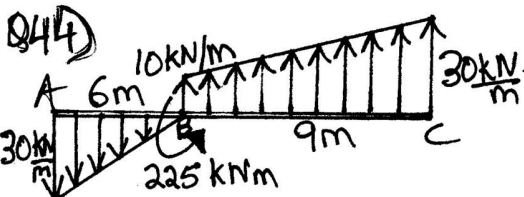
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Q43) The striker of carrom board laying on the board is being pulled by four players as shown in fig. The players are sitting exactly at the centre of the four sides. Find the resultant of forces in magnitude and direction.



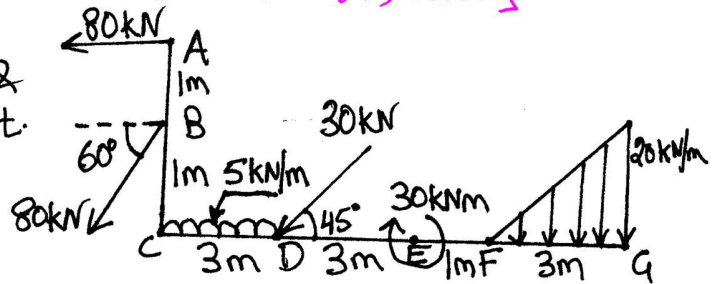
$EF_x = 20.26, EF_y = 20.89$



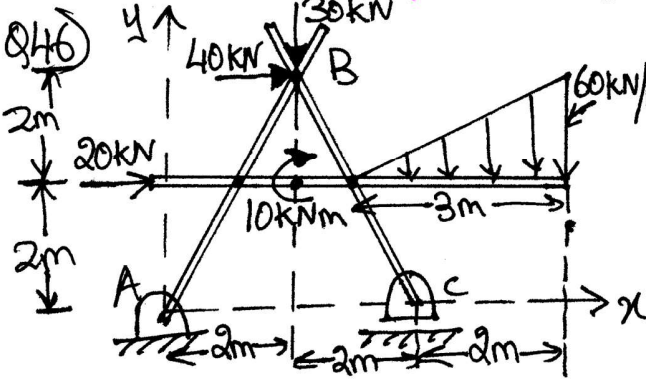
Find (i) magnitude (ii) Position along AC of the resultant

$[R = 90 \text{ kN} (\uparrow), 2.3 \text{ m}]$

Q45) Find the resultant & point of application w.r.t. point C



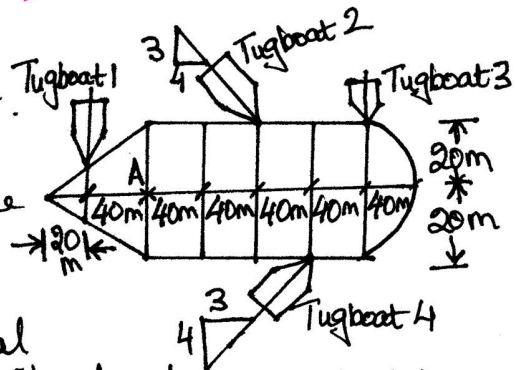
$[95.7 \text{ kN}, 43.89^\circ \swarrow, 0.95 \text{ m}]$



Find the position (x-axis intercept), magnitude & direction of the resultant 'R' of only the active force acting on A-frame structure

$[134.16 \text{ kN}, 63.43^\circ \swarrow, 6 \text{ m}, 12 \text{ m}]$

Q47) Four tugboats are used to bring an ocean liner to its pier. Each tugboat exerts a 100 kN push in direction shown. Find the point on hull w.r.t. A where a single tugboat should push to produce same effect as original four tugboats. Also find total push & its direction exerted by the single tugboat.

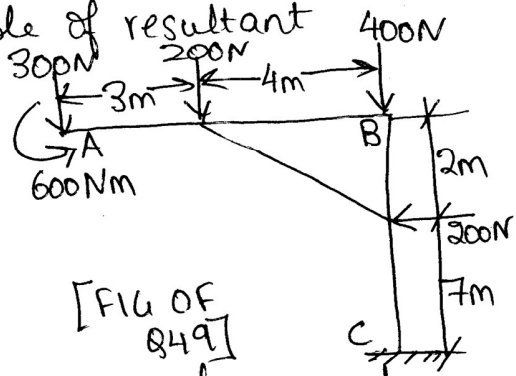
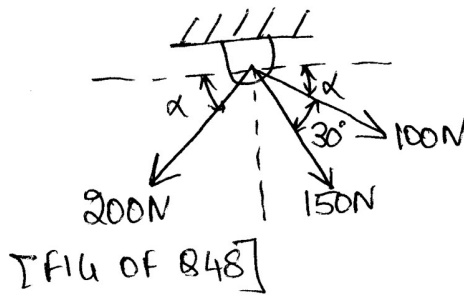


$[228.04 \text{ kN}, 52.13^\circ \swarrow, 42.22 \text{ m}, 54.29 \text{ m}]$



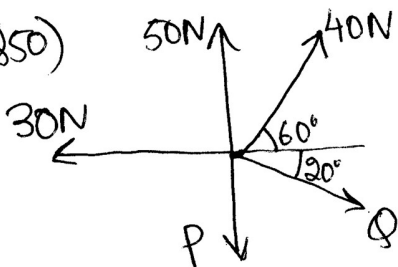
Q48) For the system shown, determine:-

- (i) The required value of α if resultant of three forces is to be vertical
- (ii) The corresponding magnitude of resultant

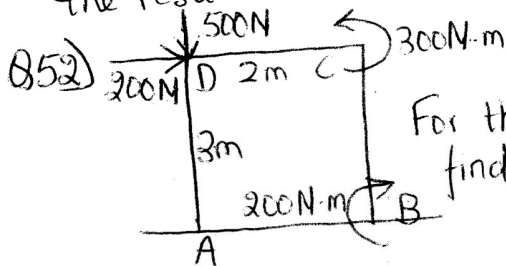
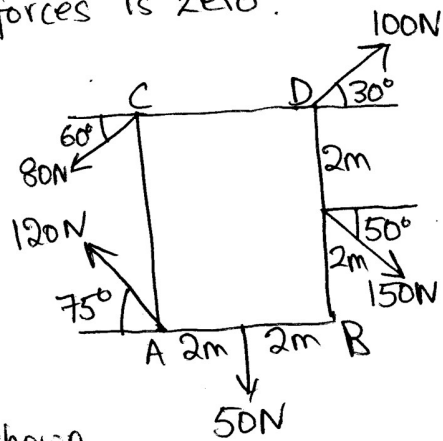


Q49) Replace the loading on the frame by a force and moment at point A.

Q50) Five concurrent coplanar forces act on a body as shown in figure. Find the forces P and Q such that resultant of the five forces is zero.



Q51) Determine the resultant of the system of forces shown in figure. Locate the point where the resultant cuts base AB.



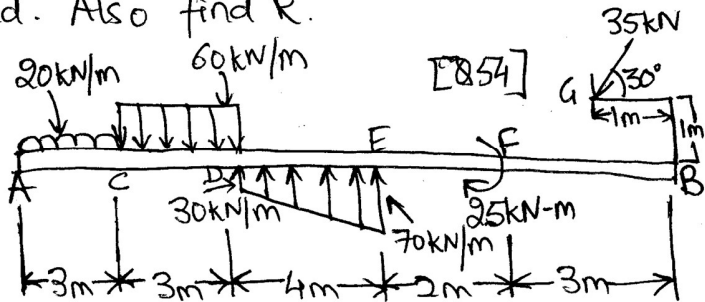
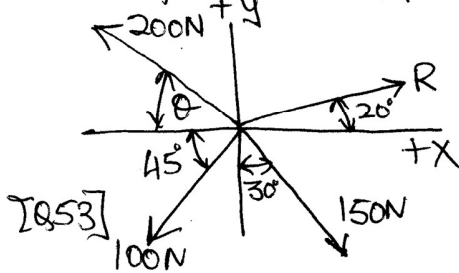
For the figure shown, find resultant force and moment at point A



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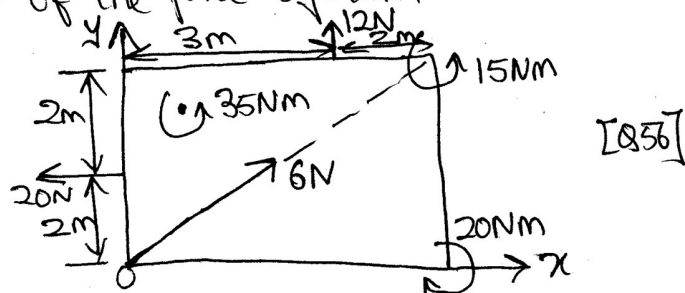
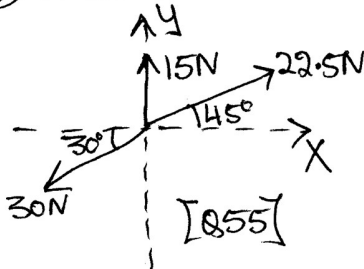
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Q53) If force R is the resultant of the remaining 3 concurrent forces shown in fig, find angle θ at which 200N force is applied. Also find R.



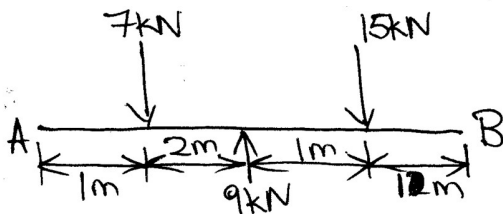
Q54) Replace the given force system (refer above fig) with a force and couple at point 'F'

Q55) Find the resultant of the force system



Q56) Replace the system of forces and couples by a single force and locate the point on x-axis through which the line of action of the resultant passes

Q57) The resultant of 3 forces shown in figure and other 2 forces P and Q acting at 'A' and 'B' is a couple of magnitude 120kNm clockwise. Determine the force P and Q.



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Practice Questions

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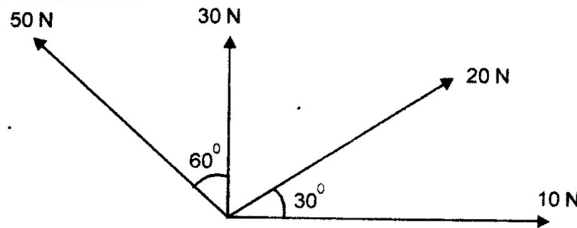
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P1. Two forces of 18 N and 35 N act away from a point. If the angle between the forces is 45° , find the magnitude of the resultant and the angle made by it with the 18 N force.

P2. The sum of the magnitudes of two forces acting at a point is 20 N and their resultant, which is perpendicular to the smaller force is 12 N. Find the magnitudes of the two forces.

P3. There are four concurrent forces of 10, 20, 30 and 40 N acting at 40° , 80° , 120° and 160° from the x axis. Find their resultant.

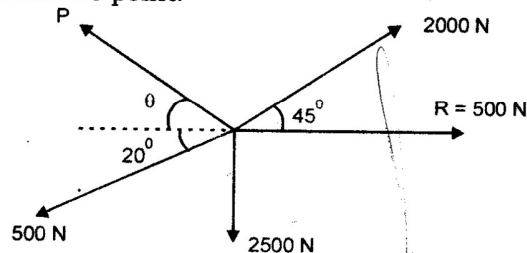
P4. Four concurrent forces act at a point as shown. Find their resultant.



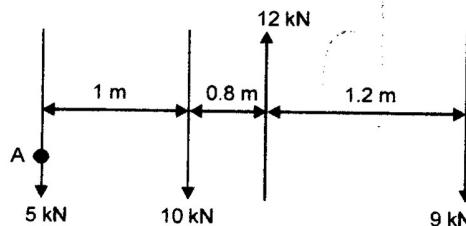
P5. Find magnitude and direction of the resultant of the following force system acting at a point.

- i. 4 N acting due North.
- ii. 3 N acting N-W towards the point
- iii. 1.5 N acting due East.
- iv. 1 N acting 30° West of South away from the point.
- v. 5 N acting 60° North of West away from the point.

P6. The resultant of a system of forces shown is 500 N and acts horizontally to the right. Find the magnitude and direction of the unknown force P acting in the system.



P7. Determine the magnitude and position of the resultant with respect to point A, of the parallel forces shown.



P8. Four parallel forces are acting on a beam. Forces A and C act upwards while forces B and D act downward. Magnitudes of A, B, C, D are 25 N, 35 N, 40 N and 50 N respectively. Distances between AB, BC, CD are 800 mm, 1000 mm and 1200 mm. Calculate the magnitude, nature and position of the resultant from force A.

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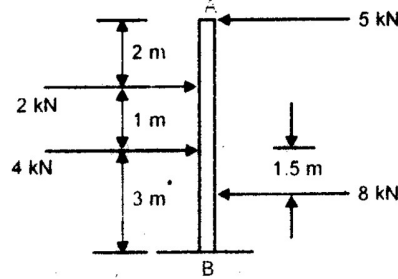


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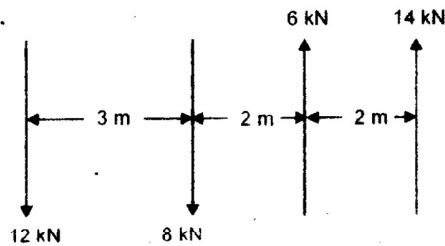
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P9. Find the magnitude of two like parallel forces acting at a distance of 50 cm apart, if their resultant is 300 N and acts at a distance of 20 cm from one of the force:

P10. Find the magnitude, nature and position of the resultant of the four parallel forces from B.

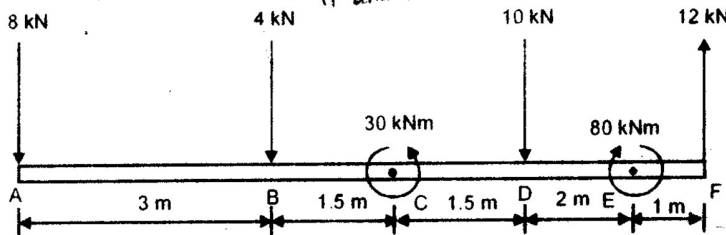


P11. Determine the resultant of the parallel forces shown.

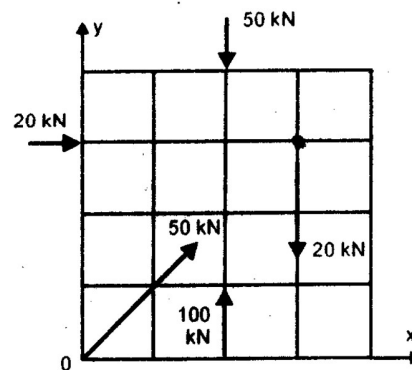


P12. Figure shows a parallel system of four forces and two couples.

- Replace it by a single force and obtain its location from point A
- Replace it by a single force and single couple at point A.
- Replace it by a single force and a single couple at point D.
- Replace it by two parallel forces at B and D.



P13. Determine the resultant of the force system shown. The side of each small square is 1 m. The overall size of the body is 4 m × 4 m.



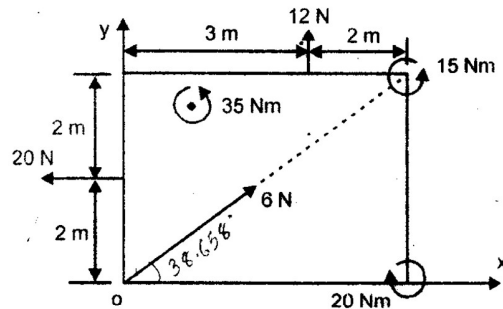
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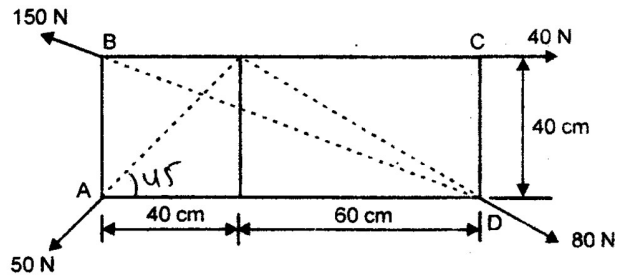
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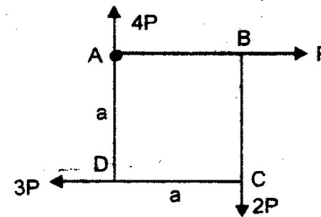
P14. Replace the system of forces and couples by a single force and locate the point on the x-axis through which the line of action of the resultant passes.



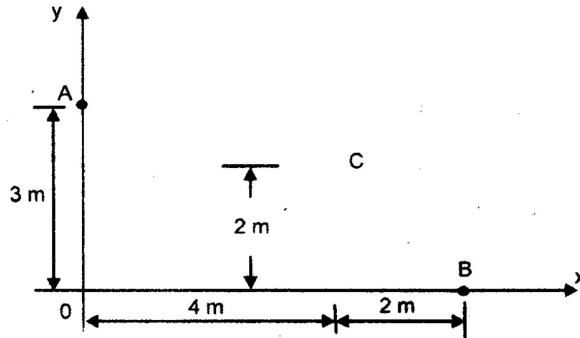
P15. A block ABCD of 100 cm × 40 cm dimensions is acted upon by four forces as shown. Calculate the resultant and then state its position with reference to A.



P16. Four forces are acting on a square of side 'a' as shown. Find the magnitude, direction and position of the resultant force.

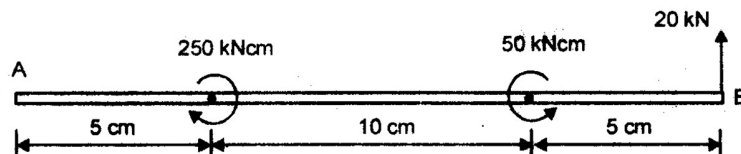


P17. Figure shows points A, B and C lying in the x-y plane. The moment of a certain force F acting in the x-y plane is 180 Nm clockwise around the origin O and 80 Nm anti-clockwise around point B. If the moment around C is zero, determine;



- The magnitude and the direction of the force F and
- The moment of the force around point A.

P18. Replace the force system acting on a bar as shown in figure by a single force.

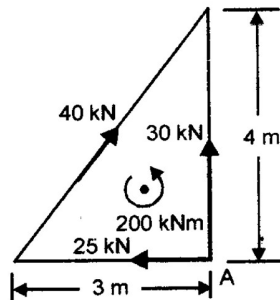


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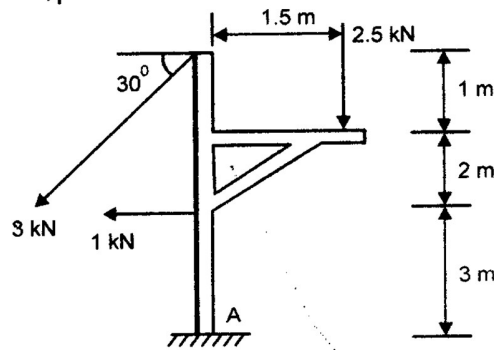
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P19. Determine the resultant of the three forces and a couple acting on a triangular plate and its location w.r.t. point A.



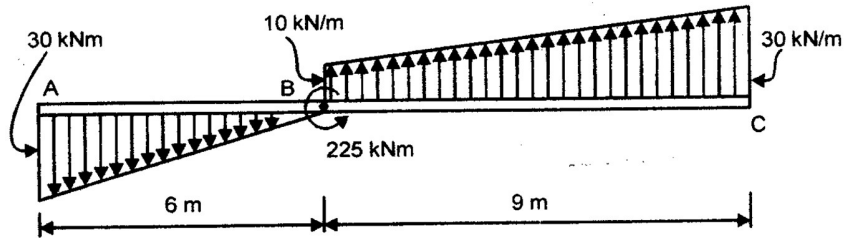
P20. Three forces 1 kN, 3 kN and 2.5 kN act on a vertical pole 6 m high.

- Find the magnitude, direction and position of resultant w.r.t A
- The position where the resultant cuts the pole from the base
- Reduce it to a force couple system at A.



P21. A member ABC is loaded by distributed load and pure moment as shown in fig., find

- magnitude of resultant
- position along AC of the resultant.





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ANSWERS

- P1.** $R = 49.39$, $\theta = 30.06^\circ$
- P2.** 6.4 N , 13.6 N
- P3.** $R = 77.75 \text{ N}$ at $\theta = 57.8^\circ$ ↗
- P4.** $R = 66.9 \text{ N}$ at $\theta = 76.2^\circ$ ↗
- P5.** $R = 5.37 \text{ N}$ at $\theta = 83.36^\circ$ ↗
- P6.** $P = 1333 \text{ N}$, $\theta = 70.53^\circ$
- P7.** $R = 12 \text{ kN} \downarrow$ at \perp distance $d = 1.28 \text{ m}$ right of A
- P8.** $R = 20 \text{ N} \downarrow$ at \perp distance $d = 5300 \text{ mm}$ to the right of force A.
- P9.** 120 N and 180 N
- P10.** $R = 7 \text{ kN} \leftarrow$ at \perp distance $d = 3.14 \text{ m}$ above B.
- P11.** Resultant is a couple of 104 kNm ↻
- P12.** i. $R = 10 \text{ kN} \downarrow$ at \perp distance $d = 1.4 \text{ m}$ to right of A.
ii. Single force at A = $10 \text{ kN} \downarrow$ and couple at A = 14 kNm ↻
iii. Single force at D = $10 \text{ kN} \downarrow$ and couple at D = 46 kNm ↻
iv. $15.33 \text{ kN} \downarrow$ at B and $5.33 \text{ kN} \uparrow$ at D.
- P13.** $R = 85.64 \text{ kN}$ at $\theta = 49.73^\circ$ ↗ at \perp distance $d = 0.23 \text{ m}$ to left of O
- P14.** $R = 21.96 \text{ N}$ at $\theta = 45.8^\circ$ ↗ cuts the x-axis at 6.73 m
- P15.** $R = 72.18 \text{ N}$ at $\theta = 19.44^\circ$ ↗. At \perp distance $d = 6.465 \text{ cm}$ right of A.
- P16.** $R = 2.83 P$ at $\theta = 45^\circ$ ↗. At \perp distance $d = 1.06a$ left of D.
- P17.** $F = 43.46 \text{ N}$ at $\theta = 85.59^\circ$ ↘, $M_A^F = 170 \text{ Nm}$ clockwise.
- P18.** $R = 20 \text{ kN}$ at 10 cm right of A.
- P19.** $R = 62 \text{ kN}$ at $\theta = 89^\circ$ ↗ at \perp distance $d = 1.677 \text{ m}$ right of A.
- P20.** a. $R = 5.38 \text{ kN}$ at $\theta = 48^\circ$ ↗ at \perp $d = 2.76 \text{ m}$ left of A
b. 4.124 m
c. $R = 5.38 \text{ kN}$ at $\theta = 48^\circ$ ↗ and $M = 14.84 \text{ kNm}$ ↻
- P21.** $R = 90 \text{ kN} \uparrow$ at $x = 23 \text{ m}$ right of A

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