Navlakhi™

An Intellectual Development

Mechanics

Chapter 2: Equilibrium

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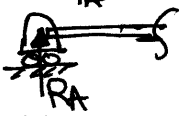
EQUILIBRIUM

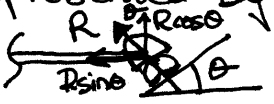
Conditions for Equilibrium are (i) $\Sigma F_x = 0$ (ii) $\Sigma F_y = 0$ (iii) $\Sigma M_A = 0$

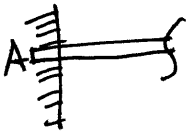
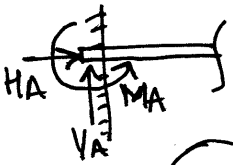
Types of Support :-

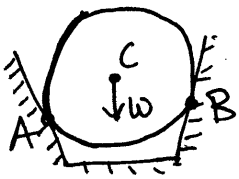
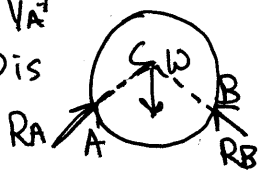
(1) Hinge Support  ∴ FBD is 

(2) Roller Support  ∴ FBD is 

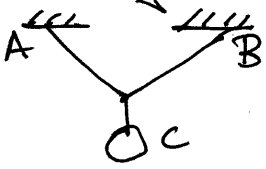
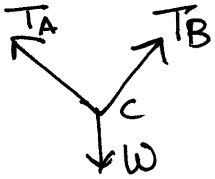
Roller support is also represented by :-

(i)  (ii)  (iii)  

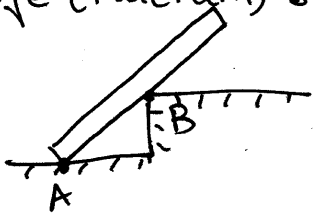
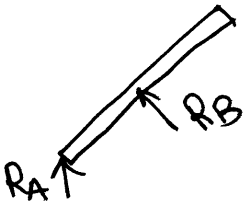
(3) Fixed Support  ∴ FBD is 

(4) Smooth surface support  FBD is 

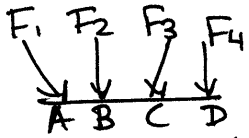
(5) Rope or String or Cable :-

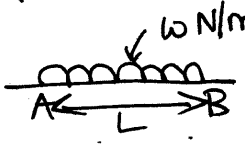
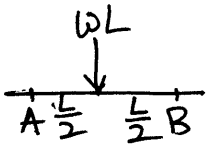
(6) Edge (Fulcrum) support

 FBD is 

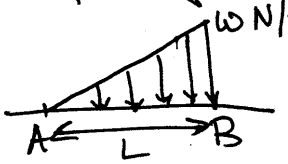
Types of Loads :-

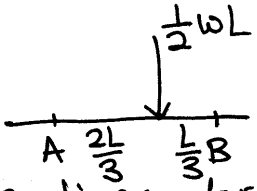
(1) Point Load :- 

(2) Uniformly distributed Load (udl)

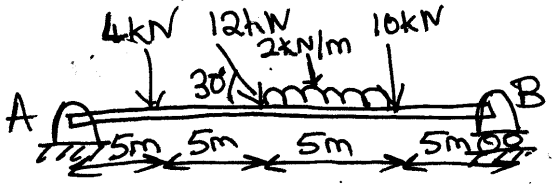
 FBD is 

(3) Uniformly varying Load (uvl)



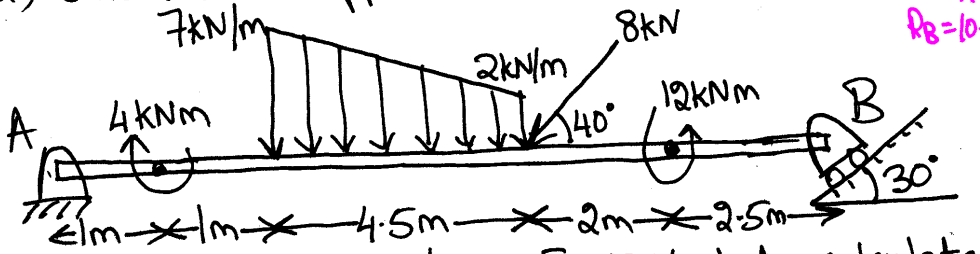


Q1) Calculate support reactions for :-



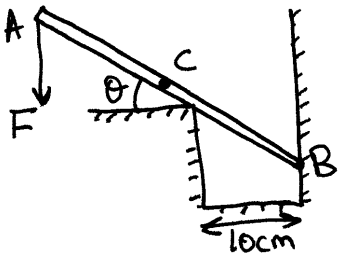
[$H_A = 10.39kN \leftarrow$
$V_A = 12.25kN \uparrow$
$R_B = 17.75kN \searrow$]

Q2) Calculate support reactions :-



[$H_A = 11.54kN \rightarrow$
$V_A = 16.02kN \uparrow$
$R_B = 10.82, \theta_B = 60° \nearrow$]

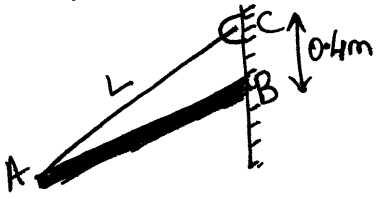
Q3) Rod of 25N has a force F = 50N at A, calculate θ and support reactions for equilibrium.
Given AB = 30cm.



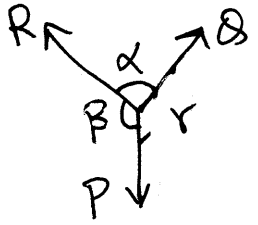
[$\theta = 42.54°$,
$R_C = 101.79N \nearrow 47.46°$,
$R_B = 68.82N \leftarrow$]

Q4) Rod AB has length 0.8m and weight W. Calculate length L of the string for equilibrium.

[1.058m].

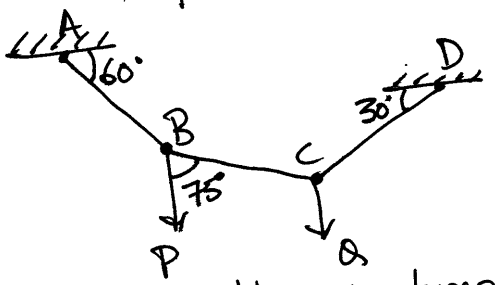


LAMI'S THEOREM :-



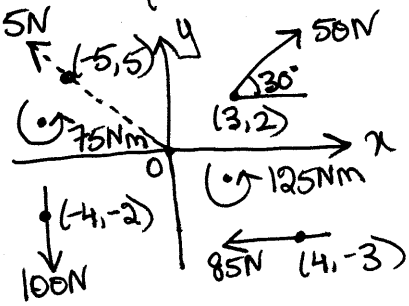
$$\frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{R}{\sin\gamma}$$

Q5) String ABCD has loads P = 50kN and Q. Find Q and tensions in different portions of the string.



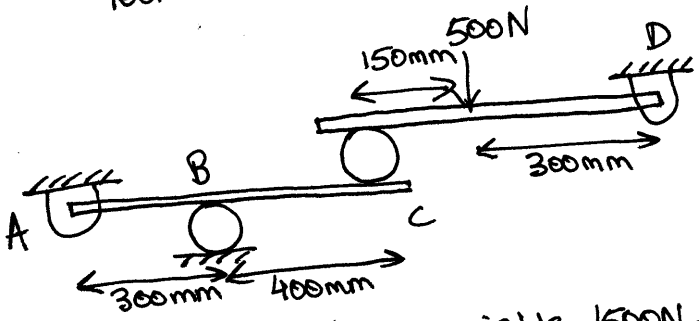
[Q = 28.86kN,
T_{AB} = 68.3kN,
T_{BC} = 35.35kN,
T_{CD} = 39.43kN]

Q6) Find the equilibrant force



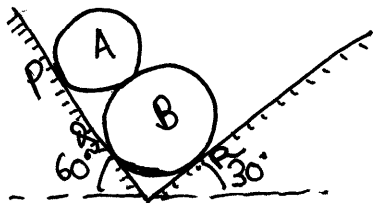
[92.34N, θ = 18.33°
d = 3.61m left of O]

Q7)



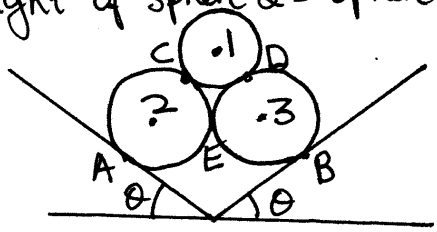
[V_D = 166.67N↑,
H_D = 0, R_C = 333.33N
R_B = 777.7N↑,
V_A = 444.4N↓,
H_A = 0]

Q8) Spheres A and B have weights 1500N, 2500N and radius 300mm & 500mm resp. Calculate reactions at P, Q & R



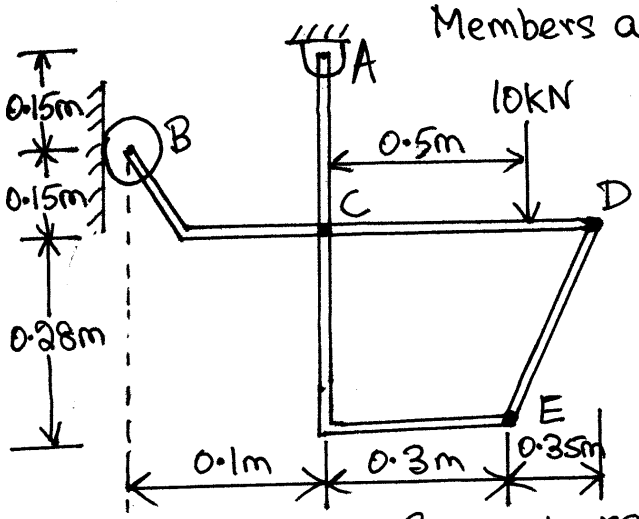
[1085.4N,
914.6N,
3664.1N]

Q9) Three surfaces rest against two surfaces. Calculate
(i) Reaction forces at points of contact when $\theta = 30°$
(ii) Minimum angle θ for which spheres remain in equilibrium
[Weight of sphere 1 = 500N & radius of sphere 1 = 0.2m,
Weight of sphere 2 = sphere 3 = 1000N & radius = 0.4m]



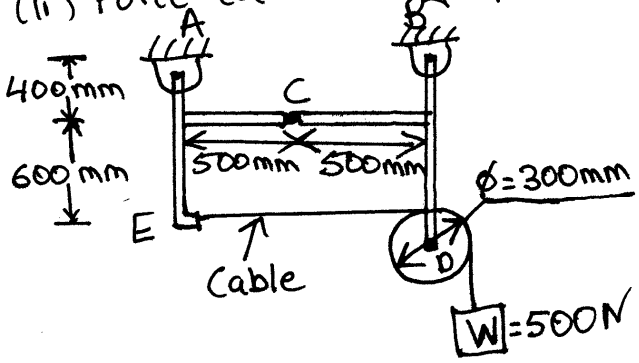
[$R_A = R_B = 1443.3N$,
$R_C = R_D = 335.4N$,
$R_E = 498.1N$.
$\theta = 10.14°$ ($R_E = 0$)]

Q10) Calculate (i) Support reactions (ii) Pin reaction at C as it acts on BCD (iii) Force in DE
Members are AE, BCD, DE



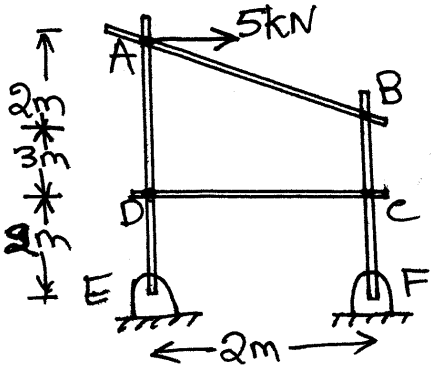
[$H_A = 33.33kN \leftarrow$,
$V_A = 10kN \uparrow$,
$R_B = 33.33kN \rightarrow$,
$V_C = 5.38kN \downarrow$,
$H_C = 52.56kN \leftarrow$,
$H_D = 19.23kN \leftarrow$,
$V_D = 15.38kN \downarrow$]

Q11) Calculate (i) Support reactions at A and B
(ii) Force carried by pin D as it supports the pulley



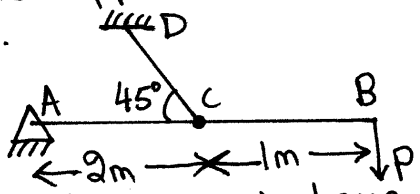
[$H_A = 843.7N \rightarrow$,
$V_A = 75N \downarrow$, $V_B = 575N \uparrow$
$H_B = 843.7N \leftarrow$]
[$H_D = 500N \rightarrow$,
$V_D = 500N \uparrow$]

Q12) Find support reactions and force at B, C, D.



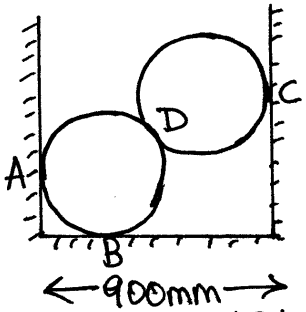
[H_E = 31.25kN ←, V_E = 17.5↓, H_F = 26.25→, V_C = 17.5↑, H_B = 17.5kN, V_B = 17.5kN, V_C = 0, V_D = 0, H_C = 43.75kN, H_D = 43.75]

Q13) Rod AB is hinged to rod CD at point C, a vertical load is applied at B. Find direction of reaction at A.



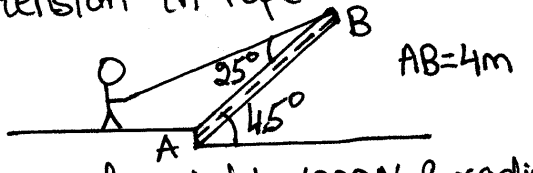
[θ = 18.43°]

Q14) Two spheres each have weight 100N and radius 250mm. Calculate reaction at A, B, C, D.



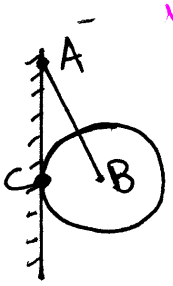
[R_A = 133.33N →, R_B = 200N↑, R_C = 133.33N ←, R_D = 166.67N 36.87]

Q15) A man raises 10kg joist of 4m by a rope. Find tension in rope and reaction at A



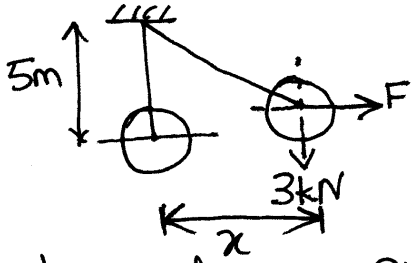
[T = 82.07N, H_A = 77.12N→, V_A = 126.17N↑]

Q16) Sphere of weight 1000N & radius 20cm hangs on rod AB = 40cm. Calculate tension in rod and reaction at C.



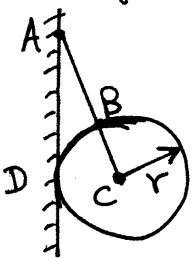
[T = 1154.7N, R_C = 577.35N →]

Q17) Calculate x such that string of 5m holding 3kN weight can be pulled before the string breaks. Also find F if string can withstand maximum force of 8kN.



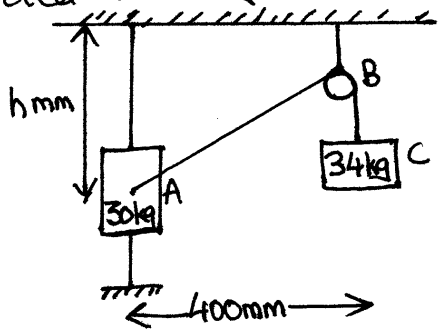
[F = 7.42kN
x = 4.64m]

Q18) A sphere of mass 2kg is connected by chain AB equal to radius of sphere. Find tension in chain and reaction of wall.



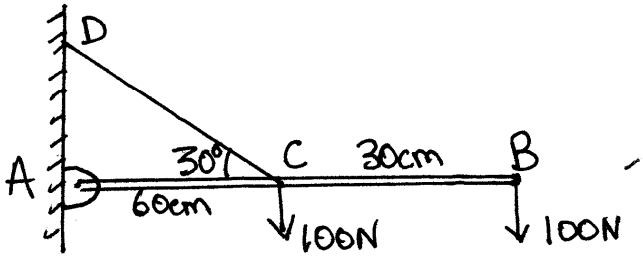
[T = 22.66N,
R_D = 11.33N]

Q19) A 30kg collar slides on frictionless vertical rod & is connected to 34kg counter weight. Find 'h' for equilibrium



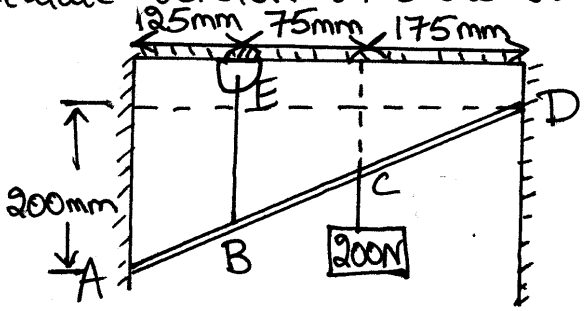
[h = 750 mm
θ = 28.07° ↙↗]

Q20) Calculate horizontal and vertical components of reaction at A and tension in rod CD



[T = 500N,
H_A = 433.01N →
V_A = 50N ↓]

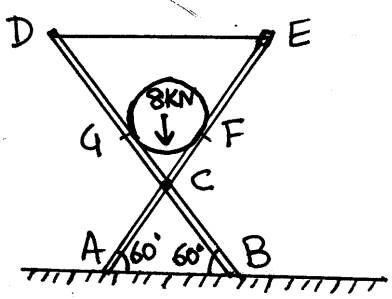
Q21) Calculate tension in cable BE & reactions at A & D.



[$R_A = 75N \rightarrow$
$R_D = 75N \leftarrow$
$T = 200N \uparrow$]

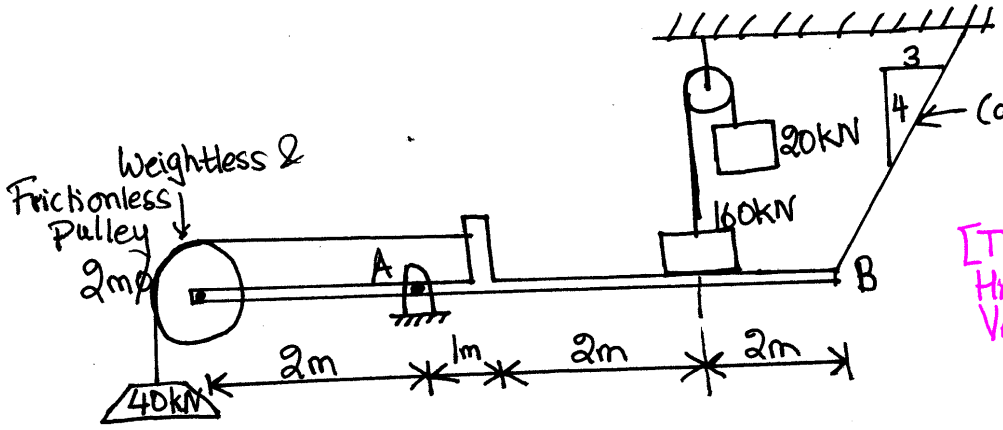
Q22) Cylinder of weight 8kN and diameter 2m is resting on pinned bar structure. Find tension in DE.

$BC = AC = 2m$
$CD = CE = 5m$



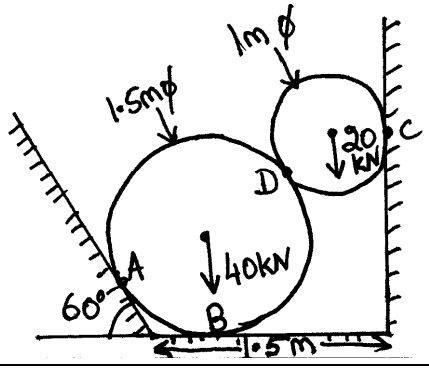
[$T = 3.69kN$]

Q23) Find beam reactions at A and B.



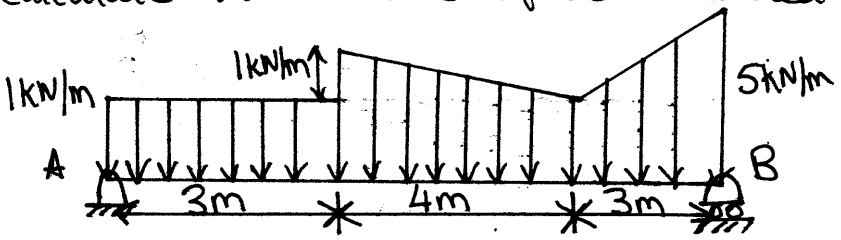
[$T = 75kN$,
$H_A = 45kN \leftarrow$
$V_A = 120kN \uparrow$]

Q24) Find reactions at A, B, C, D.



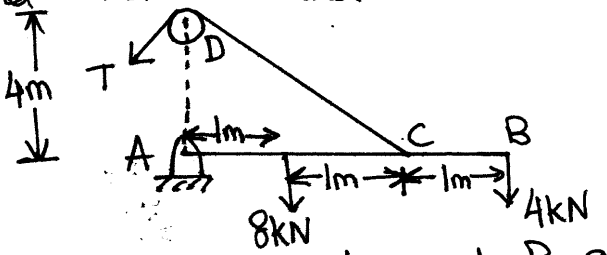
[$R_A = 11.754kN$ ∠30°,
$R_B = 54.123kN (\uparrow)$,
$R_C = 10.18kN (\leftarrow)$,
$R_D = 22.44kN$]

Q25) Calculate the reactions of beam loaded as shown



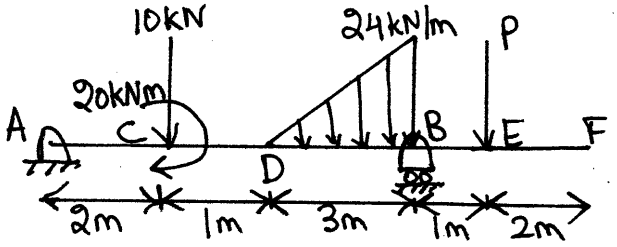
[$H_A = 0$, $V_A = 6.73$kN↑ $V_B = 11.27$kN↑]

Q26) Find tension T and reaction at pin support A.



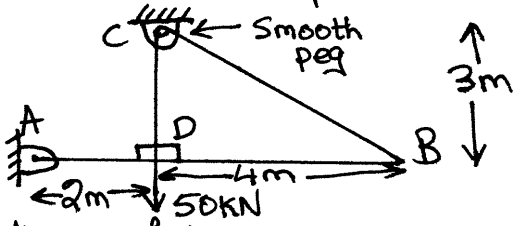
[$T = 11.19$kN, $R_A = 5.39$kN ∠21.8°]

Q27) Find support reaction at B and load P if the reaction at support A is zero.



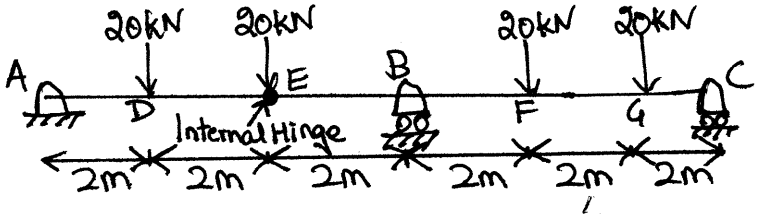
[$P = 56$kN, $V_B = 102$kN↑]

Q28) A uniform beam AB hinged at A, is kept horizontal by supporting and settling a 50kN weight with help of string tied at B and passing over smooth peg C. Find reaction at A and C if beam weighs 25kN.



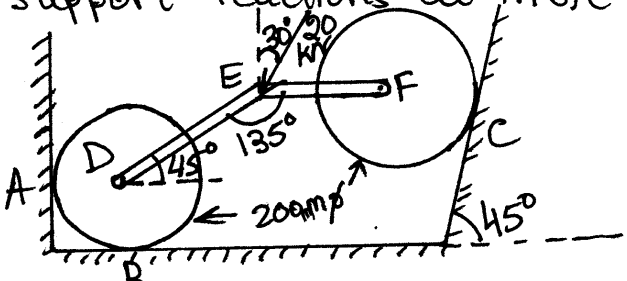
[$H_A = 25$kN(→) $V_A = 25$kN(↑) $H_C = 25$kN(←) $V_C = 50$kN(↑)]

Q29) Find reactions of beam



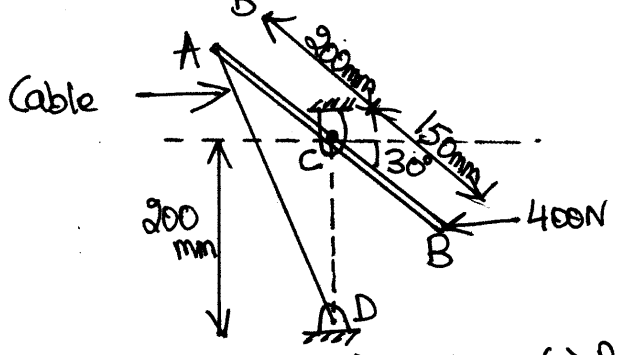
[$H_A = 0$, $V_A = 10$kN(↑) $V_B = 60$kN(↑) $V_C = 10$kN(↑)]

Q30) Find support reactions at A, B, C if DE = EF = 0.3m



[R_A = 12.14 kN (→)
R_B = 15.18 kN (↑)
R_C = 3.03 kN 45°]

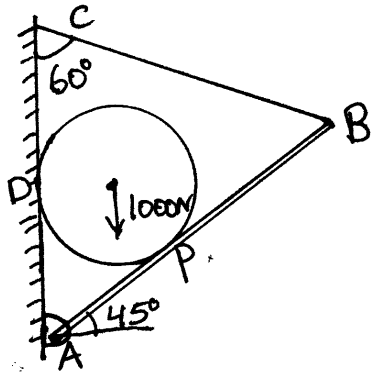
Q31)



[T = 300 N
R_C = 360.55
46.10°]

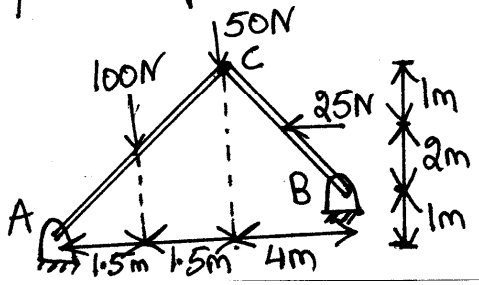
Calculate (i) Tension in cable (ii) Reaction at C.

Q32) A cylinder weighs 1000N and 1.5m diameter is supported by beam AB of length 6m and weight 400N Calculate (i) Wall reaction at D (ii) Tension in cable BC (iii) Hinge reaction at A.



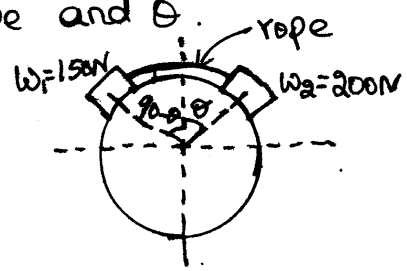
[R_D = 1000N (→)
T = 588.3N,
R_A = 1209.75
66.08°]

Q33) Find force at pin C and reactions at hinge A and B



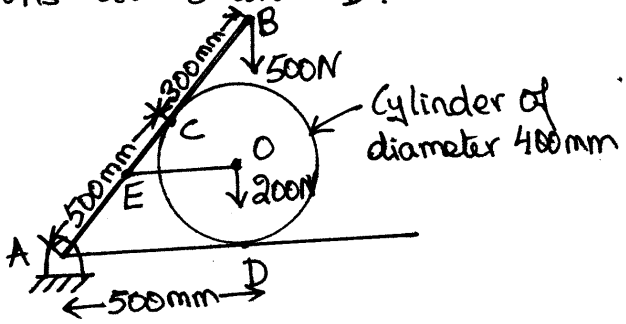
[H_A = 54N (→)
V_A = 122N (↑)
H_B = 29N (←)
V_B = 28N (↑)]

Q34) Two bodies of 150N and 200N rest on cylinder and connected by a rope. Find reaction of cylinder on bodies, tension in rope and θ.



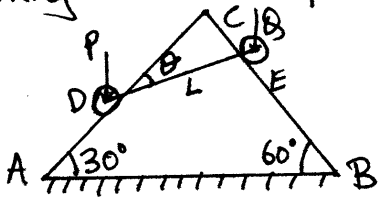
[R1=90N, R2=160N, T=120N, θ=36.87°]

Q35) A cylinder of diameter 400mm has weight 200N. Find (i) Reaction at hinge A (ii) Tension in wire OE (iii) Reactions at C and D.



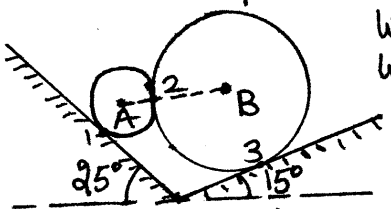
[HA=0, VA=79N↓ T=551.7N, RC=800N, RD=779N↑]

Q36) Weight of spheres D and E are P and Q which are connected by string DE. Find θ for equilibrium.



$\theta = \tan^{-1}\left(\frac{\sqrt{3}Q}{P}\right)$

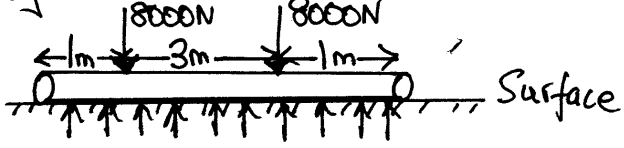
Q37) Find the reaction forces at points 1, 2 and 3.



Wt. of A = 1kg.
Wt. of B = 4kg.

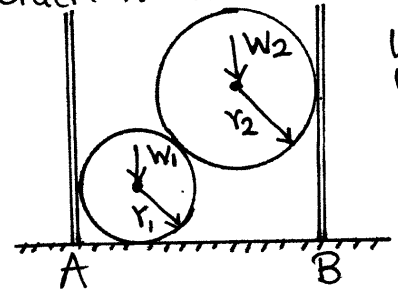
[R1=19.73N, R3=32.22N, R2=11.61N]

Q38) Find uniform reaction from surface on cylindrical log. The self weight of log is 1300 N/m & two loads are 8000N each.



[4500N/m↑]

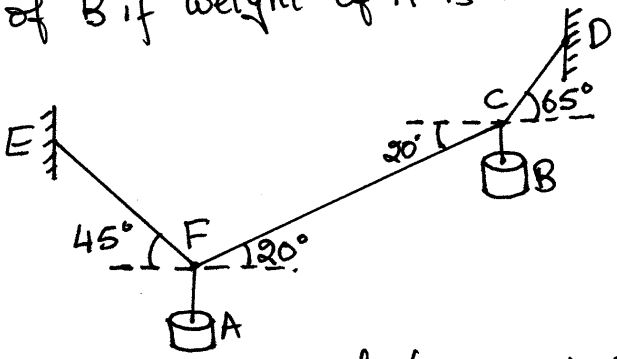
Q39) A cylinder of diameter 40mm open at both ends rests on a smooth horizontal plane. Two spheres are placed in the cylinder. Find minimum weight of cylinder for which it will not tip over.



$W_1 = 400N$
$W_2 = 600N$
$r_1 = 10cm$
$r_2 = 20cm$

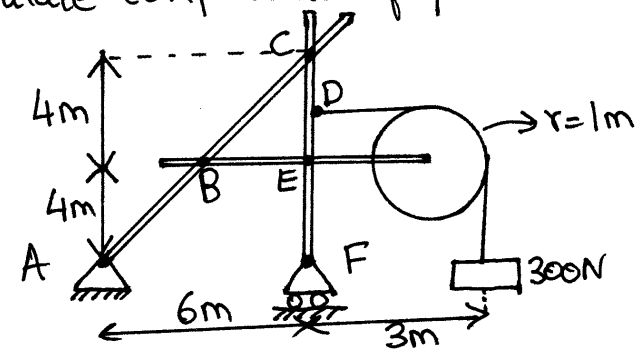
[480N]

Q40) If the cords suspend two buckets in equilibrium. Find weight of B if weight of A is 60N

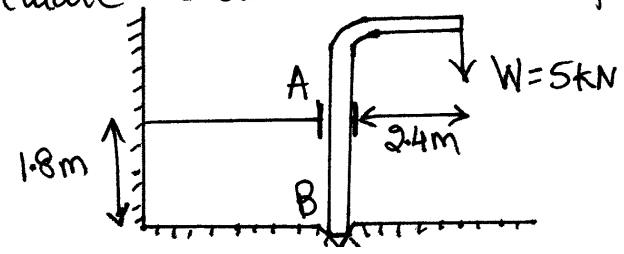


[78.32N]

Q41) Calculate components of forces at B, C, E.

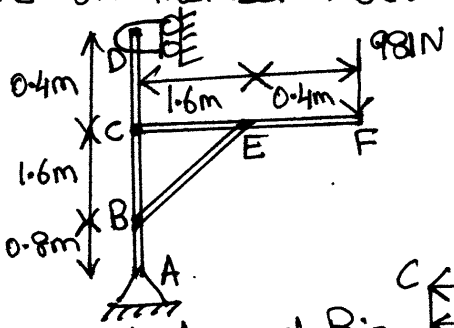


Q42) A crane is pivoted at B and supported by guide at A. Calculate reaction at A and B if W=5kN

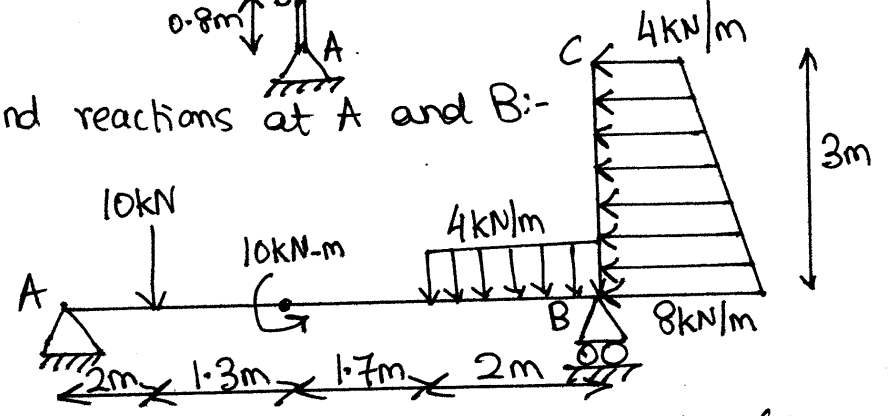


[$R_A = 6.67kN(\leftarrow)$
$R_B = 8.33kN$ (38.87)

Q43) Find horizontal and vertical component of force which pin at C exerts on member ABCD

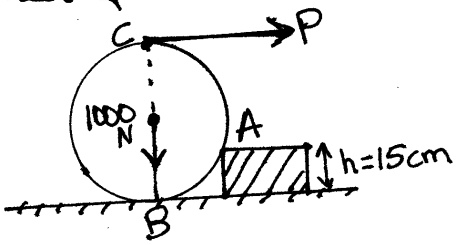


Q44) Find reactions at A and B:-



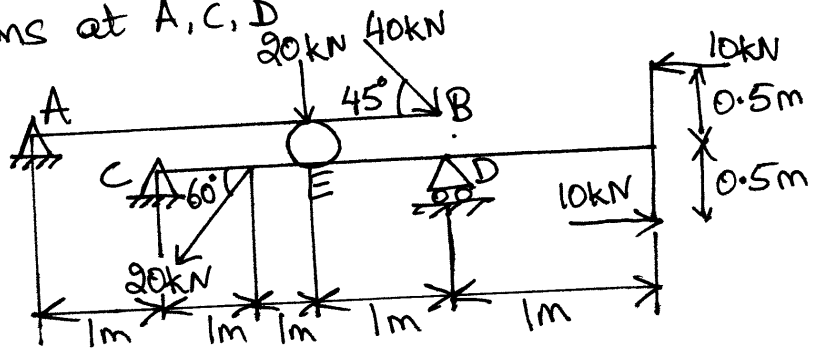
$H_A = 18KN$
$V_A = 13.15KN$
$R_B = 4.85KN$

Q45) Roller of weight 1000N and diameter 60cm. Find P when the wheel just rolls over the block

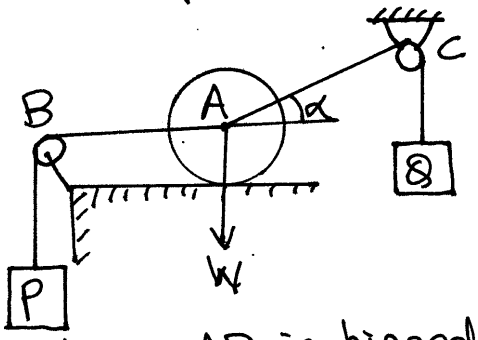


[P=577.33N]

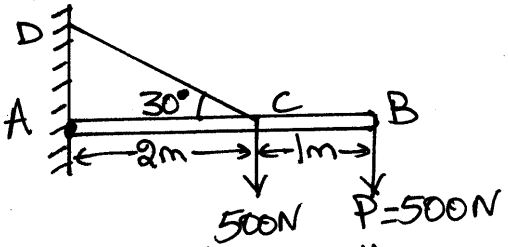
Q46) Beam AB and CF are arranged as shown. find reactions at A, C, D



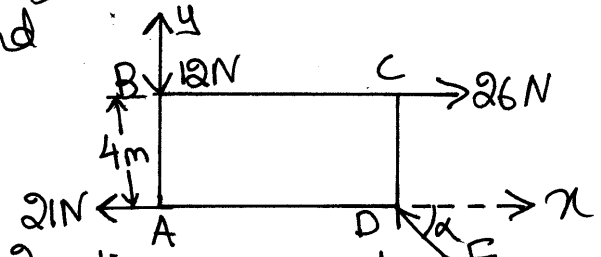
Q47) A sphere of weight W rests upon a smooth horizontal plane and has attached to its centre two strings AB & AC which pass over a frictionless pulley at B & C & carry load P & Q. Find α for equilibrium. Also find pressure between sphere & plane in terms of P, Q and W



Q48) Horizontal beam AB is hinged at A. Find tension in the rod CD and reaction at A

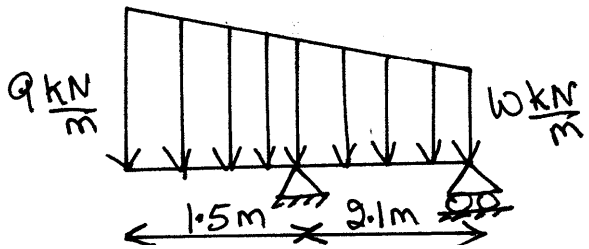


Q49) For equilibrium find
(i) force F
(ii) Angle α
(iii) Distance AD

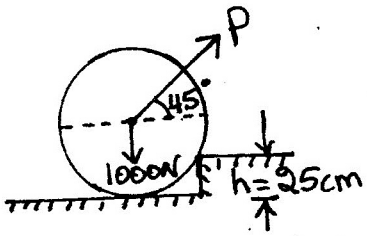


Q50) A heavy rod AB of 3m lies on ground. To lift end B off the ground needs a vertical force of 200N. To lift A end off the ground needs a force of 160N. Find weight of rod and position of centre of mass

Q51) Determine intensity of distributed load W at C if reaction at C is zero. Also find reaction at B

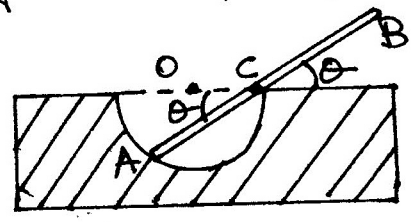


Q52) Determine force P applied at 45° just necessary to start a roller 100cm in diameter over a obstruction 25cm high if weight of roller is 1000N. Also find the magnitude and direction of P when it is minimum.



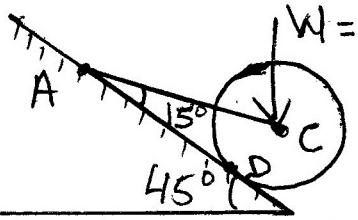
[896.48N and 866N at 60°]

Q53) A uniform rod AB of length 3R and weight W rests inside a hemispherical bowl of radius R as shown in fig. Find θ for equilibrium

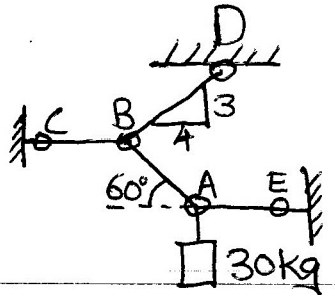


[θ=23.13°]

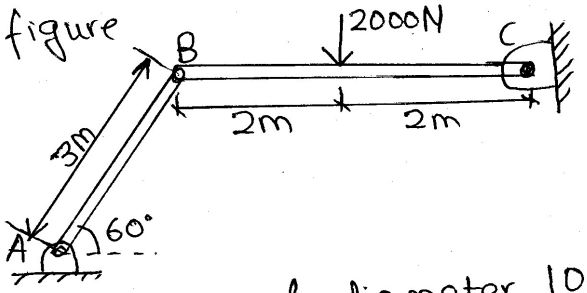
Q54) A roller of weight W=1000N rest on a smooth incline plane. It is kept from rolling down the plane by a string AC. Find the tension in the string and reaction at the point of contact D.



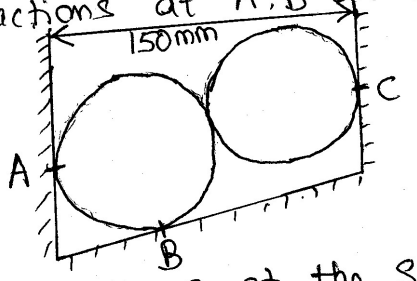
Q55) A 30kg pipe is supported at 'A' by a system of five chords. Determine the force in each chord for equilibrium



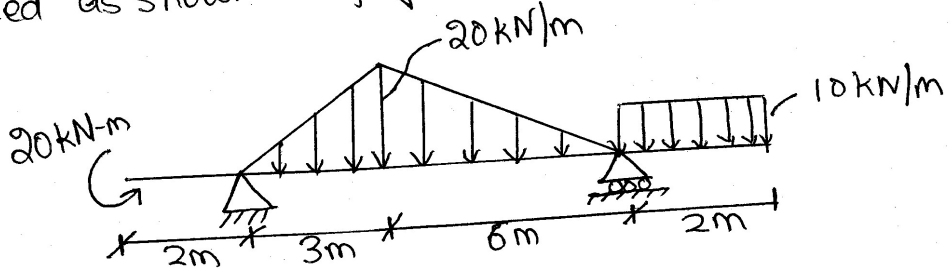
Q56) Determine reactions at A, B and C for the frame shown in figure



Q57) Two cylinders each of diameter 100mm and each weighing 200N are placed as shown in figure. Assuming that all the contact surfaces are smooth find the reactions at A, B and C

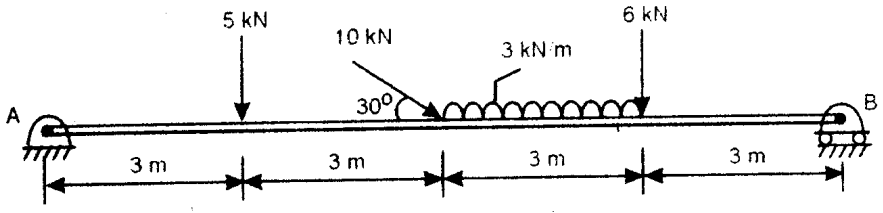


Q58) Find the reactions at the supports of the beam loaded as shown in figure

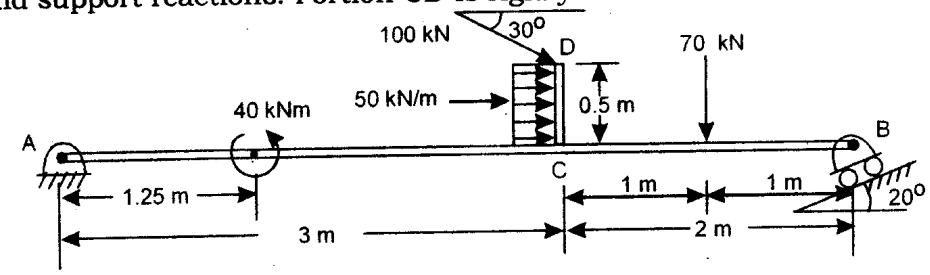


Practice Questions

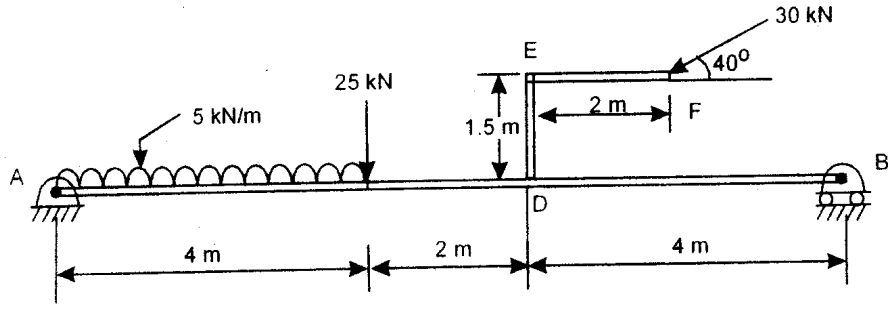
P1. A beam AB is loaded as shown. Find support reactions.



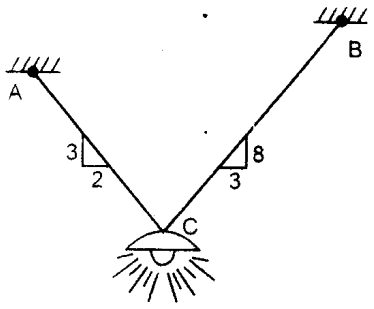
P2. Find support reactions. Portion CD is rigidly connected to the beam.



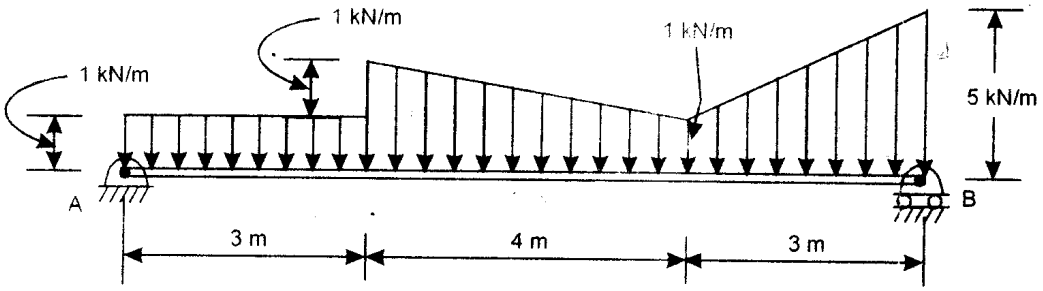
P3. Figure shows beam AB hinged at A and roller supported at B. The L shaped portion DEF is welded at D to the beam AB. For the loading shown, find support reactions.



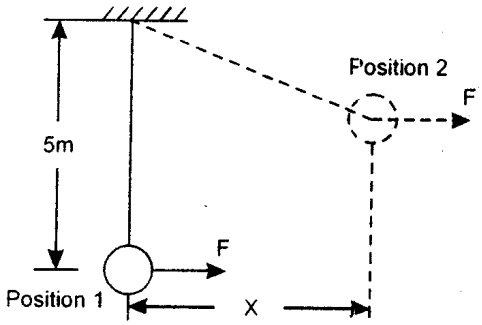
P4. A lamp weighing 150 N is supported by two cables AC and BC. Find the force developed in the cables.



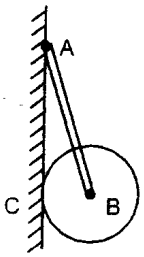
P5. Calculate the reactions of the beam loaded as shown.



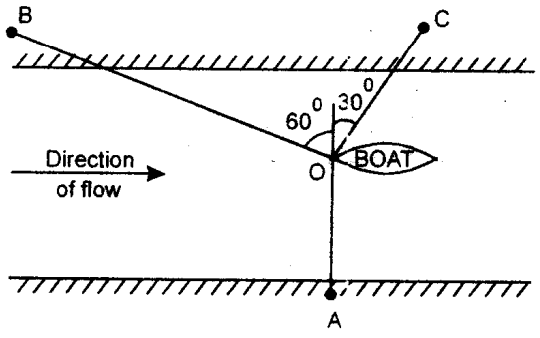
P6. Determine the horizontal distance 'x' to which a 5 m long inextensible string holding a weight of 3 kN can be pulled before the string breaks. The string can withstand a maximum force of 6 kN. Determine also the required force F.



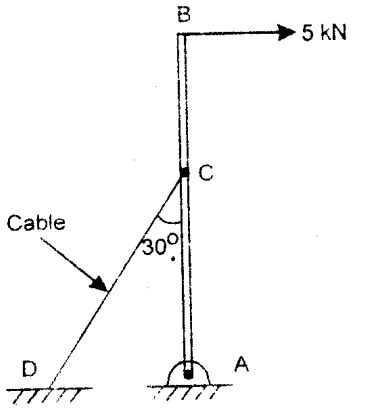
P7. A circular roller of weight 1000 N and radius 20 cm hangs by the tie rod AB = 40 cm and rests against a smooth vertical wall at C as shown. Determine the tension in the tie rod and reaction at C.



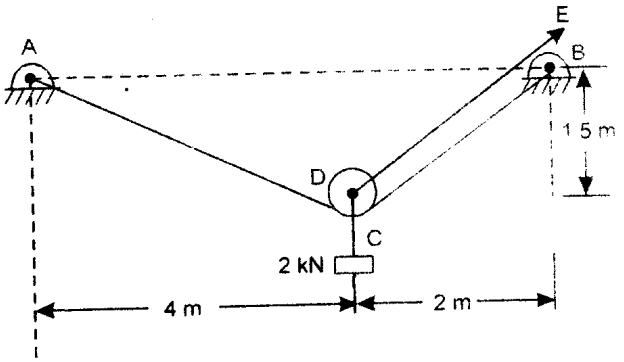
P8. A small boat is held in static by means of three inextensible taut ropes OA, OB and OC as shown. The water in the river exerts a force on the boat in the direction of flow. If the tension in OA and OB are 1 kN and 0.6 kN respectively, determine the force exerted by the flow on the boat and the tension in rope OC. Will the boat remain in equilibrium if rope OC breaks? What would then be the tension in ropes OA and OB after OC breaks?



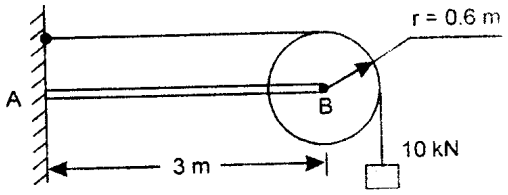
P9. A straight vertical mast 4 m long is pinned to the ground and stayed by means of a cable at a distance of 3 m from the bottom as shown. If a horizontal force of 5 kN acts at the top, determine the tension in the cable and reaction at the hinge.



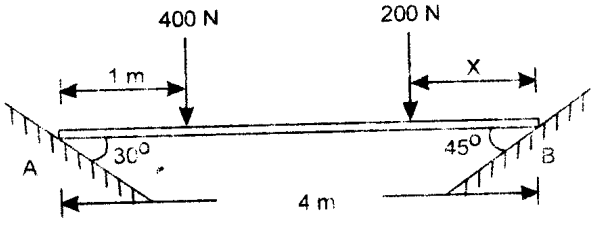
P10. A 2 kN load is attached to a small pulley which may roll on the cable ACB. The pulley and the load are held in position shown by the second cable DE which is parallel to portion CB of the main cable.
Determine
a) the reactions at A and B
b) the tension in the cable ACB
c) the tension in the cable DE
Neglect radius of the pulley



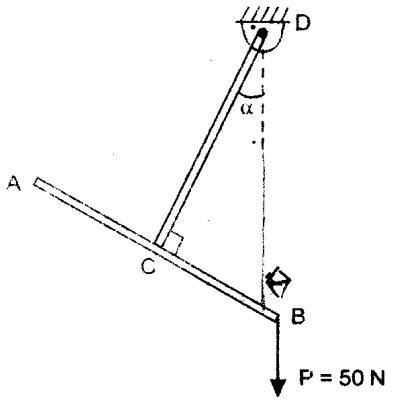
P11. A fixed bracket AB weighing 1500 N/m carries a smooth pulley of 2000 N weight at its end B. A 10 kN load hangs from the rope passing over the smooth pulley. Find support reactions.



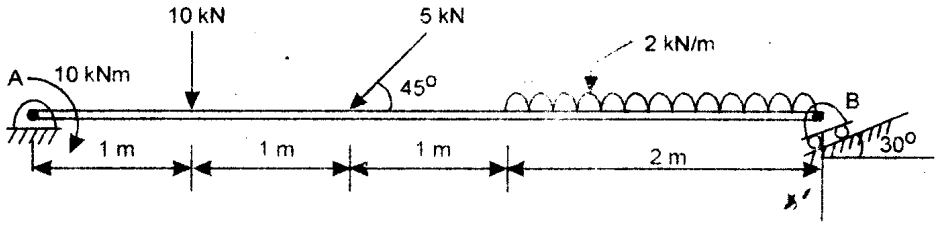
P12. A weightless bar is placed in a horizontal position on the smooth inclines as shown. Find x at which the 200 N force should be placed from point B to keep the bar horizontal.



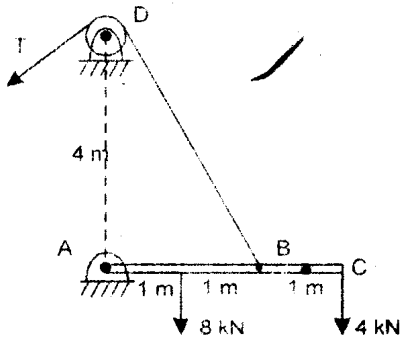
P13. Figure shows two identical bars AB and CD each of length L and weight 25 N, are welded at C to form a symmetrical T section and freely suspended at D. Calculate the angle α that the bar CD will make with vertical when P = 50 N is applied at B. Also find the support reactions.



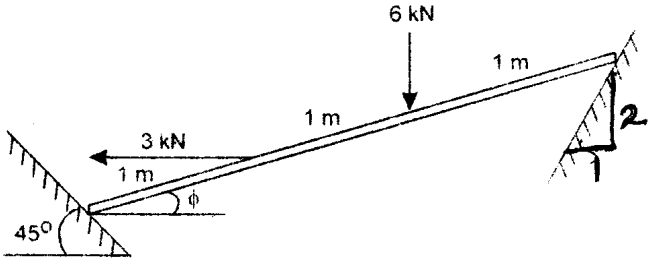
P14. Find the support reactions at A and B for the beam AB loaded and supported as shown.



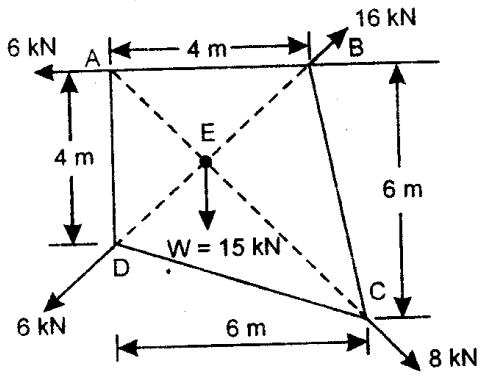
P15. Determine the tension T in the cable and the reaction at pin support A for the beam loaded as shown. Neglect weight of the beam and the size of the pulley.



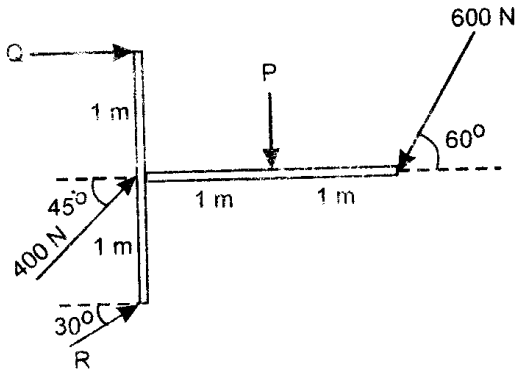
P16. Figure shows a bar 3 m long and of negligible weight resting on smooth inclined surfaces subjected to the horizontal and vertical forces of 3 kN and 6 kN respectively. Find the value of angle ϕ required for the equilibrium of the bar.



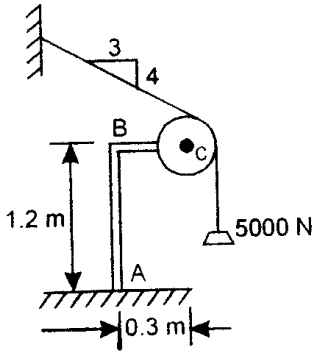
P17. A solid plate ABCD has weight of 15 kN acting at E and is held in vertical plane under forces as shown. Find an additional force P, stating its magnitude, direction and sense, such that the plate is steadily and slowly lowered down at 10 cm/sec without rotation. Find its position with respect to A.



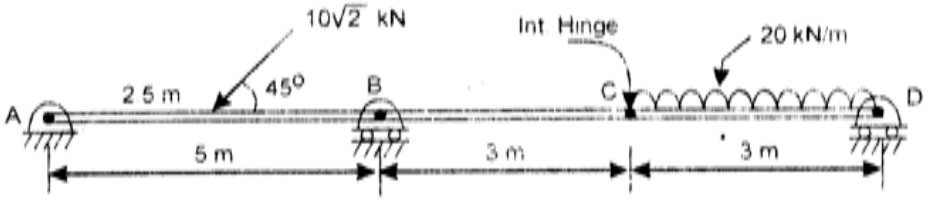
P18. The force system shown has neither a resultant force nor a resultant couple.
Find magnitude of forces P, Q and R.



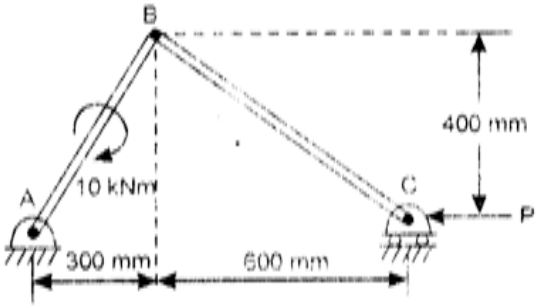
P19. A weight of 5000 N is suspended by a cable passing over a frictionless pulley attached at pin C. Find support reactions at fixed end A of column ABC.
Take radius of pulley = 150 mm.
Neglect weight of pulley, column and cable.



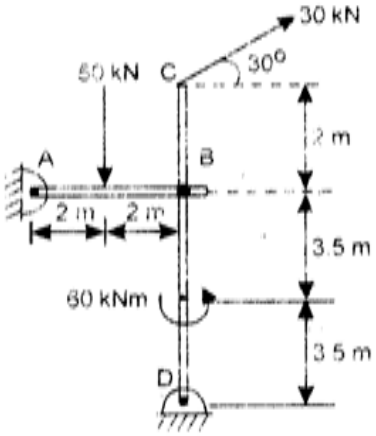
P1. A two span beam ABCD is loaded as shown. Calculate support reaction.



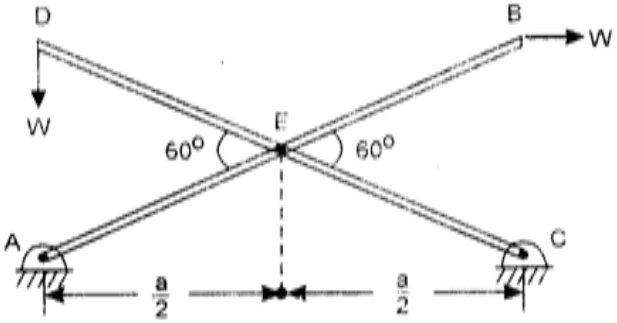
P2. A two bar mechanism is internally pinned at B and externally supported as shown. It is subjected to a moment of 10 kNm. Calculate force P required at C to maintain the configuration.



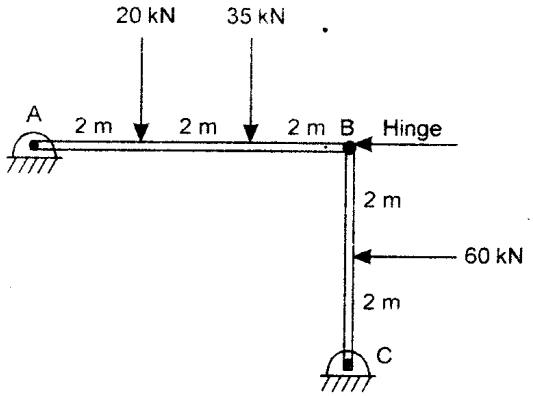
P3. Calculate support reactions at A and D in the frame. All pin connections are frictionless.



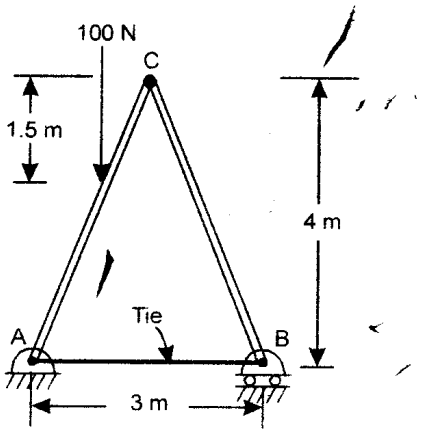
P4. An X frame is loaded and supported. Find the horizontal and vertical components of reaction at A and C.



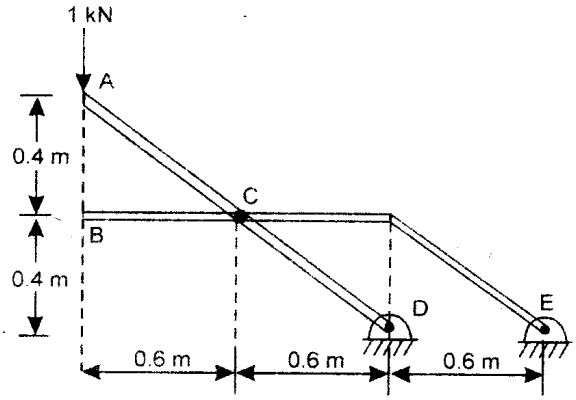
P5. Determine the reactions at A, B and C for the pin-jointed frame loaded as shown.



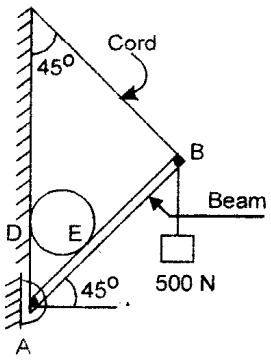
P6. Find the reactions at the supports and the force in the tie for the A frame shown.



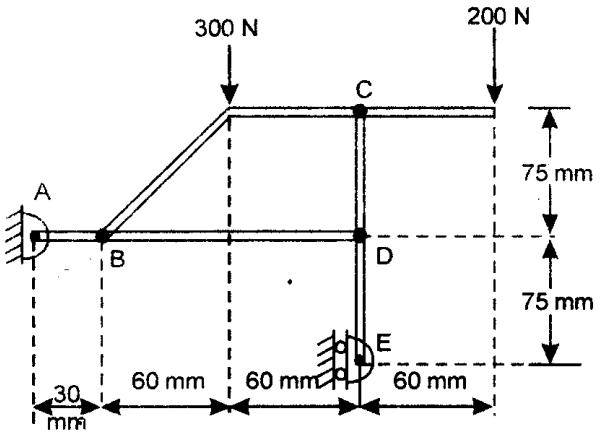
P7. Find the reactions at supports D and E if the frame shown in figure is loaded at A by a load of 1 kN. What is the force on pin at C.



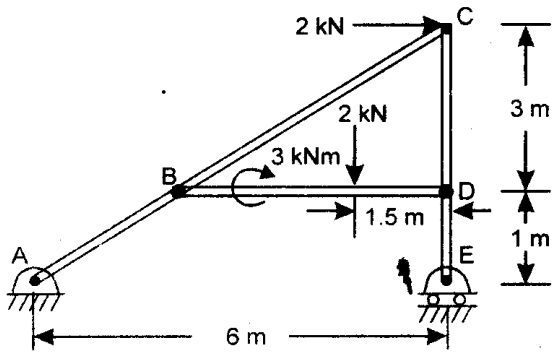
P8. A cylinder of diameter 1 m and weighing 1000 N and another block weighing 500 N are supported by a beam of length 7 m and weighing 250 N with the help of a cord as shown.
If the surfaces of contact are frictionless, determine tension in cord and reaction at point of contacts.



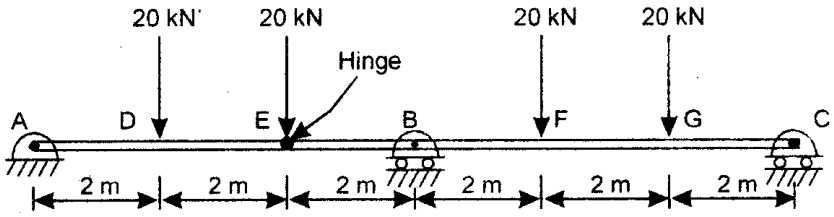
P9. For the frame and loading shown, determine the components of all forces acting on member ABD.



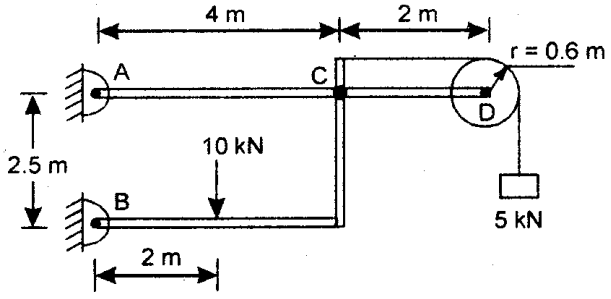
P10. Find the reactions at the supports A and E of the frame shown in figure. Also find the force in pin at B.



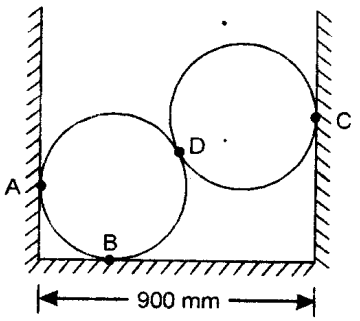
P11. Find the reactions of the beam shown in figure.



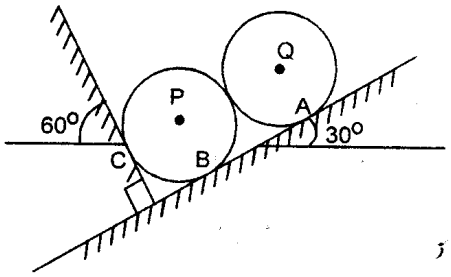
P12. Figure shows a frame in which the pulley at D has a mass of 200 kg. Neglecting the weights of the bars find out the components of hinge reaction at A, B and C.



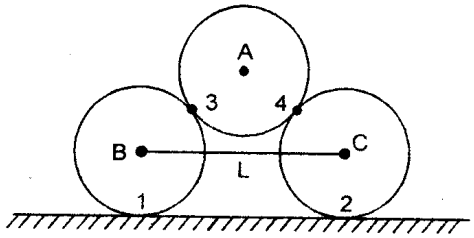
P13. Two smooth spheres of weight 100 N and of radius 250 mm each are in equilibrium in a horizontal channel of width 900 mm as shown. Find the reactions at the surface of contact A, B, C and D assuming all smooth surfaces.



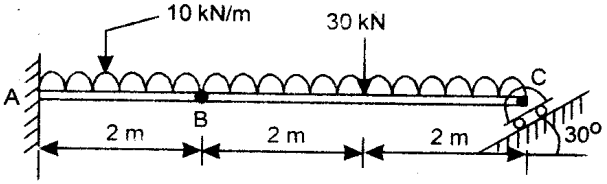
P14. Two homogenous solid cylinders of identical weight of 5000 N and radius of 0.4 m are resting against inclined wall and sloping ground as shown. Assuming smooth surfaces find the reactions at A, B and C of the contact points.



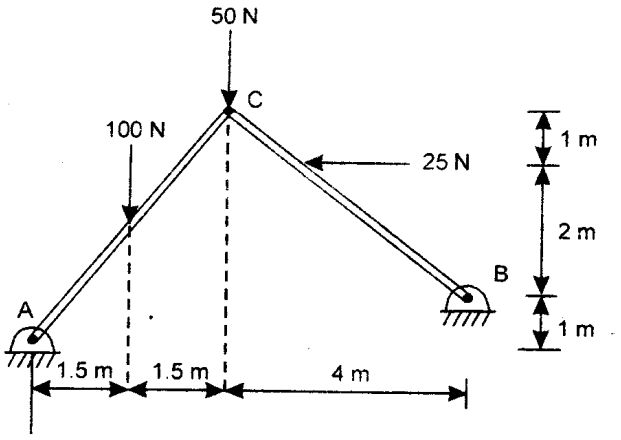
P15. Sphere A = 1000 N rests on two spheres B and C of weight 900 N each. The spheres B and C are connected by an inextensible string of length L = 600 mm. Assuming smooth contacts and radius of spheres to be 200 mm, determine the reactions at all contact points 1 to 4 and also the force in the string.



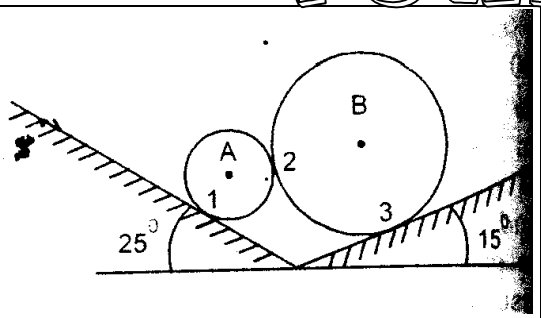
P16. A beam ABC is internally connected by a pin at B. Determine the support reactions.



P17. For a system of connected bodies find the support reactions.



P18. Determine the reactions at points of contact 1, 2 and 3. Assume smooth surfaces.
Take $r_A = 1$ cm, $r_B = 4$ cm,
$m_A = 1$ kg, $m_B = 4$ kg.



ANSWERS

P1. $H_A = 8.66$ kN ←, $V_A = 11.125$ kN ↑, $R_B = 13.875$ kN↑

P2. $H_A = 79.6$ kN←, $V_A = 32.09$ kN ↑, $R_B = 93.55$ kN $\theta = 70°$ ↘

P3. $H_A = 22.98$ kN →, $V_A = 38.3$ kN↑, $R_B = 25.98$ kN ↑

P4. $T_{AC} = 64.81$ N , $T_{BC} = 102.17$ N

P5. $H_A = 0$, $V_A = 6.74$ kN ↑, $R_B = 11.26$ kN ↑

P6. $x = 4.33$ m, $F = 5.196$ kN

P7. $T = 1154.7$ N, $R_C = 577.3$ N →

P8. Boat remains in equilibrium, Water force = 0.1156 kN, $T_{OC} = 0.808$ kN, $T_{OB} = 0.1335$ kN, $T_{OA} = 0.0667$ kN.

P9. $T = 13.33$ kN, $H_A = 1.66$ kN →, $V_A = 11.54$ kN ↑.

P10. $T_{ACB} = 1.9$ kN, $T_{DE} = 0.323$ kN, $R_A = 1.9$ kN $\theta = 20.56°$ ↘, $R_B = 1.9$ kN $\theta = 36.87°$ ↗

P11. $H_A = 10$ kN →, $V_A = 16.5$ kN ↑, $M_A = 42.75$ kNm ↺

P12. $x = 1.607$ m

P13. $\alpha = 15.94°$, $H_D = 0$, $V_D = 100$ N ↑

P14. $H_A = 8.51$kN →, $V_A = 8.92$ kN ↑, $R_B = 9.947$ kN $\theta = 60°$ ↘

P15. $T = 11.18$ kN, $H_A = 5$ kN →, $V_A = 2$ kN ↑

P16. $\phi = 45°$

P17. $P = 15.16$ kN $\theta = 63.65°$ ↘, located at ⊥ distance $d = 0.113$ m to right of A

P18. $P = 96$N ↓, $Q = 559$ N ←, $R = 665.34$ N $\theta = 30°$ ↗

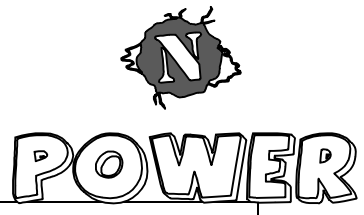
P19. $H_A = 3000$ N →, $V_A = 1000$ N ↑, $M_A = 3300$ Nm ↺

P1. $H_A = 10$ kN →, $V_A = 13$ kN ↓, $R_B = 53$ kN ↑, $R_D = 30$ kN ↑

P2. $P = 16.67$ kN

P3. $H_A = 24.83$ kN ←, $V_A = 25$ kN ↑, $H_D = 1.15$ kN ←, $V_D = 10$ kN ↑

P4. $H_A = 1.732$ W → , $V_A = 0.422$ W ↑, $H_C = 2.732$ W ←, $V_C = 0.577$ W ↑



P5. $H_A = 30$ kN →, $V_A = 25$ kN ↑,
$H_C = 30$ kN →, $V_C = 30$ kN ↑,
$H_B = V_B = 30$ kN

P6. $H_A = 0, V_A = 68.75$ N ↑,
$R_B = 31.25$ N ↑, T = 11.718 N

P7. $H_D = 6$ kN ←, $V_D = 3$ kN ↑,
$H_E = 6$ kN →, $V_E = 2$ kN ↓,
$H_C = 6$ kN, $V_C = 2$ kN, $R_C = 6.32$ kN

P8. T = 685.79N, $R_D = 1000$ N →,
$R_E = 1414.2$ N

P9. $H_A = 920$ N ←, $V_A = 500$ N ↑,
$H_B = 920$ N ←, $V_B = 625$ N ↓,
$H_D = 1840$ N →, $V_D = 125$ N ↑

P10. $H_A = 2$ kN ←, $V_A = 1.33$ kN ↓,
$R_E = 3.33$ kN ↑, Force in pin at B = 0.

P11. $H_A = 0$, $V_A = 10$ kN ↑, $R_B = 60$ kN ↑,
$R_C = 10$ kN ↑.

P12. $H_A = 25.9$ kN ←, $V_A = 3.478$ kN ↓,
$H_B = 25.9$ kN →, $V_B = 20.44$ kN ↑,
$H_C = 30.9$ kN, $V_C = 10.44$ kN

P13. $R_A = 133.3$ N →, $R_B = 200$ N ↑,
$R_C = 133.3$ N ←, $R_D = 166.6$ N

P14. $R_A = R_B = 4330$ N $\theta = 60°$ ∠,
$R_C = 5000$ N $\theta = 30°$ ∠

P15. $R_1 = R_2 = 1400$ N ↑,
$R_3 = R_4 = 755.93$ N,
T = 566.94 N

P16. $H_A = 20.2$ kN →, $V_A = 55$ kN ↑,
$M_A = 90$ kNm ↺
$R_C = 40.41$ kN, $\theta = 60°$ ∠

P17. $H_A = 54$ N →, $V_A = 122$ N ↑,
$H_B = 29$ N ↑, $V_B = 28$ N ↑

P18. $R_1 = 19.729$ N, $R_2 = 11.604$ N,
$R_3 = 32.216$ N