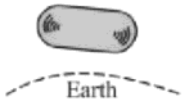
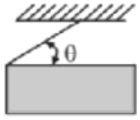
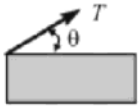
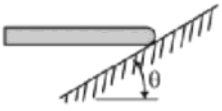
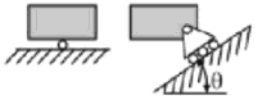
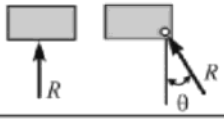
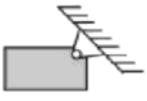
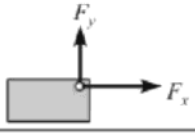
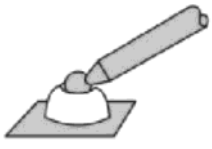
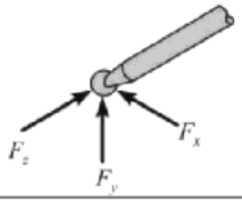
Equilibrium of Forces

06 January 2022 08:33 AM

The steps involved in drawing a free-body diagram are:

1. Draw a diagram of the body completely isolated from all other bodies. The free body may consist of an entire assembled structure or any combination or part of it.
2. Represent the action of each body or support that has been removed by a force (or its components) as shown in Table 3-2.1.
3. Label each force by its magnitude if known, or by a symbol if unknown. If the sense of an unknown force along its line of action should be incorrectly assumed, the solution will give a negative sign, but its magnitude will nevertheless be correct.

4. The free-body diagram should be legibly and neatly drawn, and of sufficient size that all pertinent data can be clearly depicted.

Type of body removed	Sketch of reacting bodies	Action of body removed on the free body
Earth		
Flexible cord, rope, or cable (weight neglected)		
Smooth surface		
Roller		
Smooth pin or hinge		
Ball-and-socket joint		

In Fig. 3-4.1, two cylinders, A of weight 400 N and B of weight 200 N, rest on smooth inclines. They are connected by a bar of negligible weight hinged to each cylinder at its geometric center by smooth pins. Find the force P acting as shown that will hold the system in the given position.

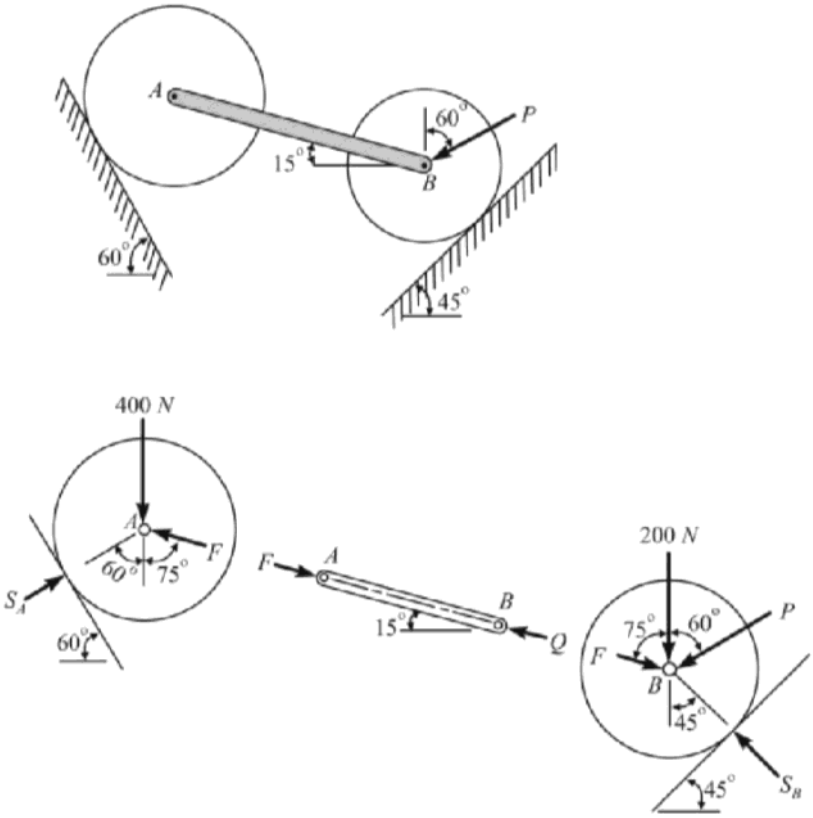


Figure 3-4.2 Free-body diagrams.

3.4.2 A 300-N box is held at rest on a smooth incline by a force P making an angle θ with the incline as shown in Fig. P.3-4.2. If $\theta = 45°$, determine the value of P.

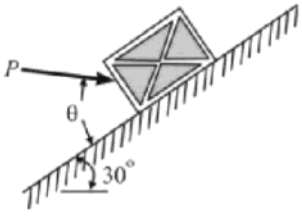


Figure P-3-4.2

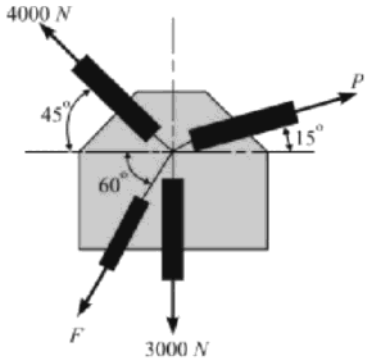


Figure P.3-4.4

3-4.5 The 300 N sphere in Fig. P-3-4.5 is supported by the pull P and a 200 N weight passing over a frictionless pulley. If $\alpha = 30°$, compute the values of P and θ.

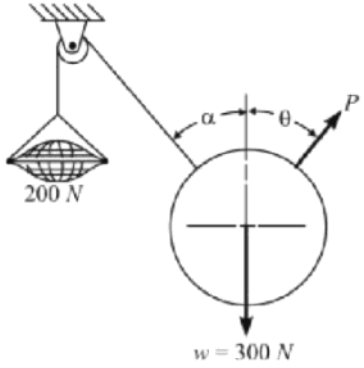
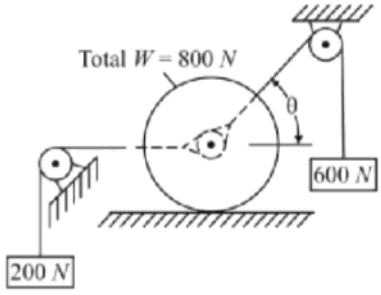


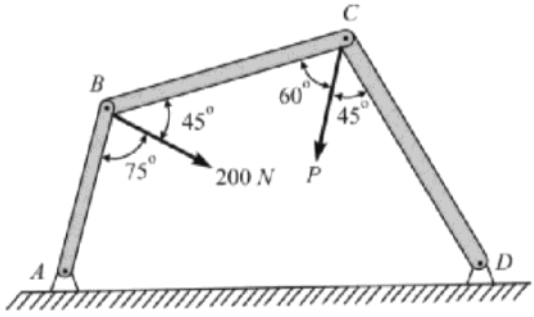
Figure P-3-4.5

3-4.7 Cords are looped around a small spacer separating two cylinders each weighing 400 N and pass, as shown in Fig. P-3-4.7, over frictionless pulleys to weights of 200 N and 600 N. Determine the angle and the normal reaction S between the cylinders and the smooth horizontal surface.



3-4.9 Three bars, pinned together at B and C and supported by hinges at A and D as shown in Fig. P-3-4.9 form a four-link mechanism. Determine the value of P that will prevent motion.

P = 304 N ***Ans.***



3-4.10 Determine the amount and direction of the smallest force P required to start the wheel in Fig. P-3-4.10 over the block. What is the reaction at the block?

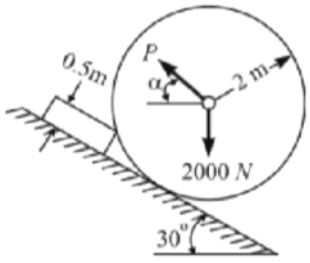
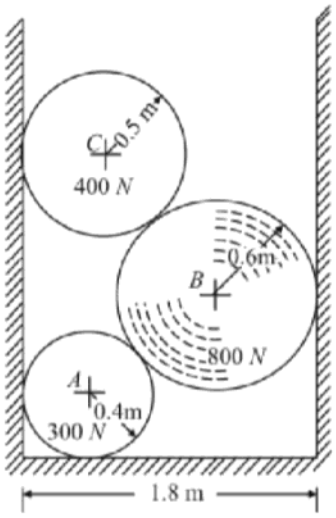


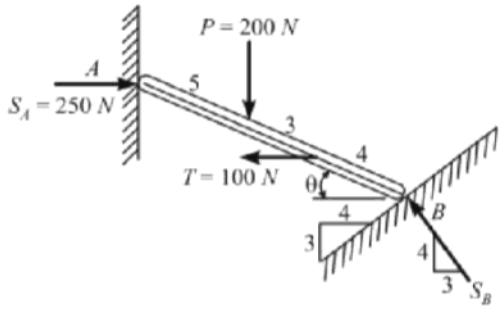
Figure P-3-4.10

P = 1893 N at 71.3° with horizontal; R = 642 N ***Ans.***

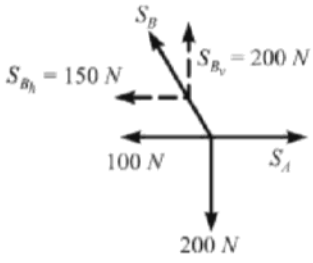
3-4.11 Three cylinders are piled in a rectangular ditch as shown in Fig. P-3-4.11. Neglecting friction, determine the reaction between cylinder A and the vertical wall.



3-5.3 A 12 m bar of negligible weight is acted upon by a vertical load $P = 200$ N and a horizontal load $T = 100$ N applied at the positions shown in Fig. 3-5.5(a). The ends of the bar are in contact with a smooth vertical wall and a smooth incline. Determine the equilibrium position of the bar as defined by the angle θ it makes with the horizontal.



(a)



(b)

3-5.5 Determine the forces *P, F*, and *T* required to keep the triangular frame *ABC* shown in Fig. P-3-5.5 in equilibrium

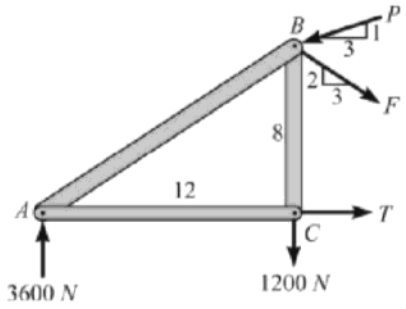


Figure P-3-5.5

$P = 6330$ N; $F = 722$ N; $T = 5400$ N ***Ans.***

3-5.6 The weight of the trapezoidal block is 7200 N acting shown in Fig. P-3-5.6. The ground reaction varies uniformly from an intensity of P_A N/m at A to P_B N/m at B. Determine P_A and P_B.

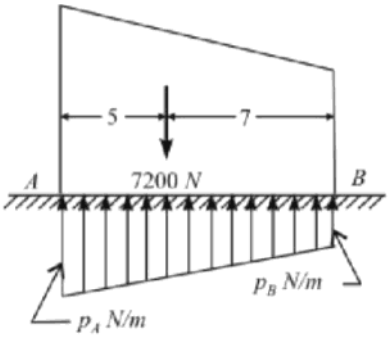


Figure P-3-5.6

$P_A = 900$ N/m; $P_B = 300$ N/m ***Ans.***

3-5.7 A beam supports a load varying uniformly from an intensity of w N/m at the left end to p N/m at the right end. Find the values of *w* and *p* to cause the reactions shown in Fig. P-3-5.7.

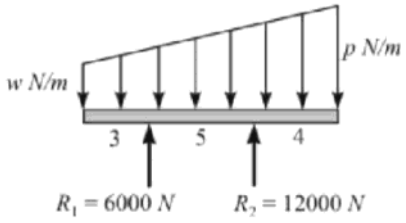


Figure P-3-5.7

$w = 1250$ N/m; $p = 1750$ N/m ***Ans***

3-5.8 As shown in Fig. P-3-5.8, the intensity of loading on a simply supported beam 10 m long is given by $y = 10x^3$ where y is in N/m and x is in m measured front A. Find the reactions at A and B.

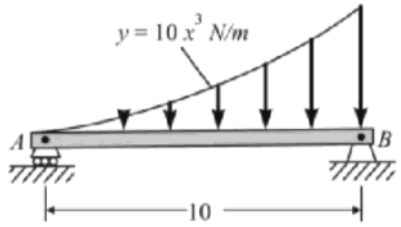


Figure P-3-5.8

3-

$R_A = 5000$ N; $R_B = 20{,}000$ N ***Ans***

3.5.12 A weight W rests on the bar AB as in Fig. P-3-5.12. The cable connecting W and B passes over frictionless pulleys. If bar AB has negligible weight, show that the reaction at A is $W(L - a)/(L + a)$.

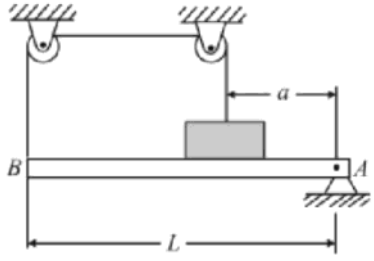
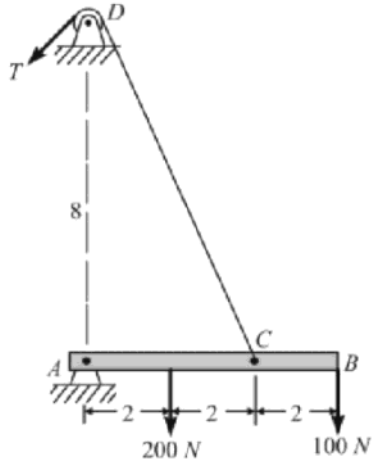


Figure P-3-5.12

3-5.13 A boom AB is supported in a horizontal position by a hinge A and a cable which runs from C over a small pulley at D as shown in Fig. P-3-5.13. Compute the tension T in the cable and the horizontal and vertical components of the reaction at A. Neglect the weight of the boom and the size of the pulley at D.



3.5.1

3.5.15 A pulley of 1m radius, supporting a load of 500 N, is mounted at B on a horizontal beam as shown in Fig. P-3-5.15. If the beam weighs 200 N and the pulley weighs 50 N, find the hinge force at *C*.

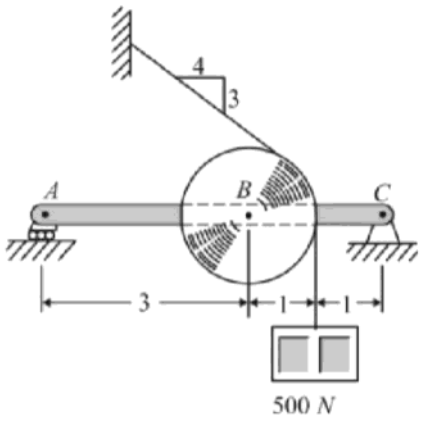


Figure P-3-5.15

$C = 472$ N up to the right at $\theta_h = 32^o$ ***Ans***

3.5.19 A 12 m bar of negligible weight rests in a horizontal position on the smooth inclines in Fig. P-3-5.19. Compute the distance x at which load T = 100 N should be placed from point B to keep the bar horizontal.

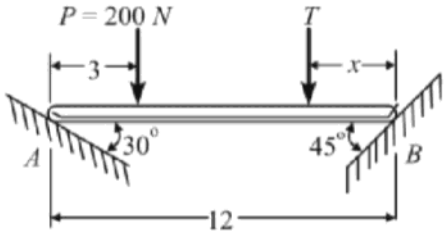


Figure P-3-5.19

$x = 4.83$ m ***Ans.***

3-5.21 Find the distance x (measured along *AB*) at which a horizontal force of 60 N should be applied to hold the uniform bar *AB* in the position shown in Fig. F-3-5.21. Bar *AB* is 10 m long and weighs 140 N. The incline and the floor are smooth.

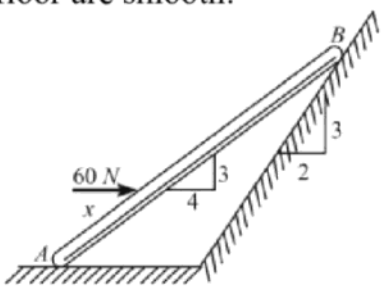


Figure P-3-5.21

$x = 3.33\text{m}$ ***Ans.***

3-5.22 Bar AB of negligible weight is subjected to a vertical force of 600 N and a horizontal force of 300 N applied as shown in Fig. P-3-5.22. Find the angle θ at which equilibrium exists. Assume smooth inclined surfaces.

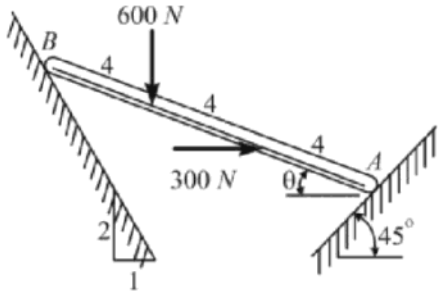


Figure P-3-5.22

$\theta = 45^{\circ}$ ***Ans.***

3-6.1 The vertical mast shown in Fig. 3-6.1 is mounted in a ball-and-socket joint at *A* and supported by two guy wires extending from *D* to anchorages at *B* and *C*. At the midpoint of the mast, a force $P = 700$ N acts parallel to the *Z* axis and a force F = 1400 N acts parallel to the *X* axis. Find the tensions in the guy wires and the reaction at A.

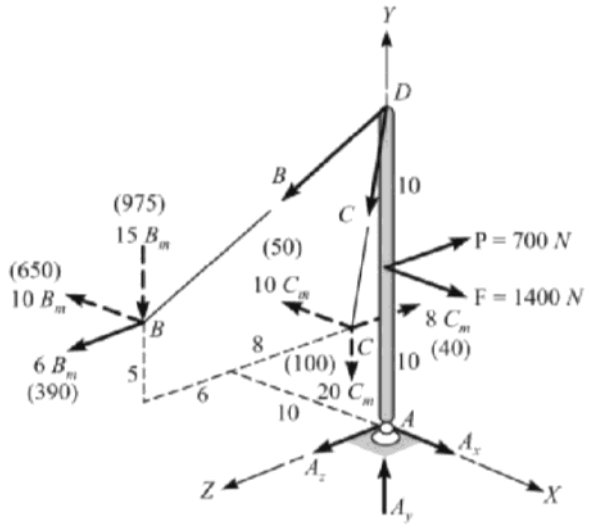


Figure 3-6.1

3-6.14 A mast *AD* is supported in a ball-and-socket joint at *A* and by two guy wires *BD* and *CD* as shown in Fig. P-3-6.14. Find the magnitude of the force *A* if $\mathbf{F} = 600\,\hat{\mathbf{i}}$ N and P $400\,\hat{\mathbf{k}}$ N.

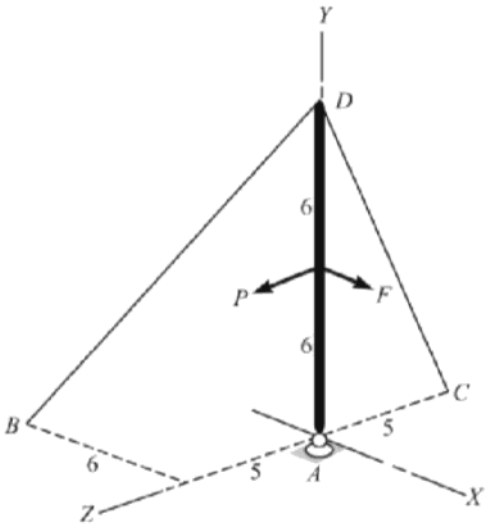


Figure P-3-6.14

A = 1718 N ***Ans.***

3-6.17 In Fig. P-3-6.17, the boom AC is supported in a ball-and-socket joint at C and by the cables AD and BE. If the weight $W = 3300$ N, find the force in the cables and the components of the reaction at C.