1. Two forces P and Q are applied as shown in figure 1 at point A of a hook support. Knowing that P = 75 N and Q = 125 N, Determine the magnitude and direction of their resultant. **(R=179 N and α=104.5° in third quadrant from x-axis)**

SOLUTION

Using the triangle rule and the law of cosines:

$$20° + 35° + \alpha = 180°$$

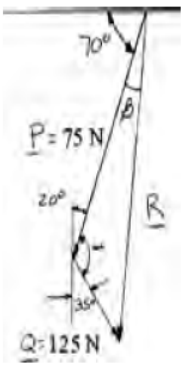
$$\alpha = 125°$$

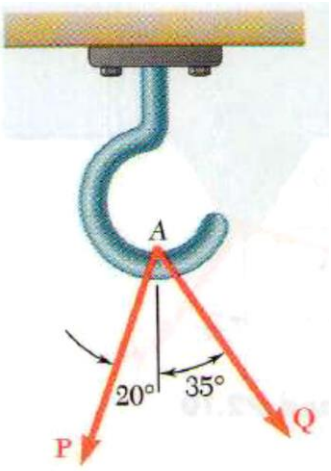
$$R^2 = P^2 + Q^2 - 2PQ\cos\alpha$$

$$R^2 = (75\text{ N})^2 + (125\text{ N})^2 - 2(75\text{ N})(125\text{ N})\cos 125°$$

$$R^2 = 32004.56$$

$$R = 178.898\text{ N}$$





Using the law of sines:

$$\frac{\sin\beta}{125\text{ N}} = \frac{\sin 125°}{178.898\text{ N}}$$

$$\beta = 34.915°$$

$$70° + \beta = 104.915°$$

$$\mathbf{R = 178.9\text{ N} \angle 104.9°} \blacktriangleleft$$

2. Two forces are applied as shown in figure 2 to a hook support. Knowing that the magnitude of P is 35 N, determine (a) the required angle if the resultant R of the two forces applied to the support is to be horizontal (b) the corresponding magnitude of R. **(α=37.1° & R=73.2 N)**

SOLUTION

Using the triangle rule and law of sines:

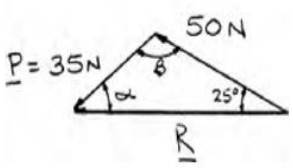
(a)

$$\frac{\sin\alpha}{50\text{ N}} = \frac{\sin 25°}{35\text{ N}}$$

$$\sin\alpha = 0.60374$$

$$\alpha = 37.138°$$

$$\alpha = 37.1° \blacktriangleleft$$



(b)

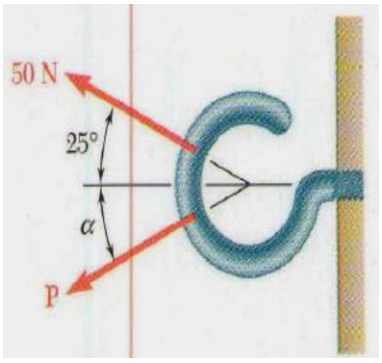
$$\alpha + \beta + 25° = 180°$$

$$\beta = 180° - 25° - 37.138°$$

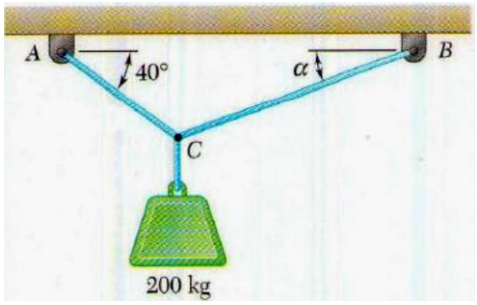
$$= 117.86°$$

$$\frac{R}{\sin 117.86} = \frac{35\text{ N}}{\sin 25°}$$

$$R = 73.2\text{ N} \blacktriangleleft$$

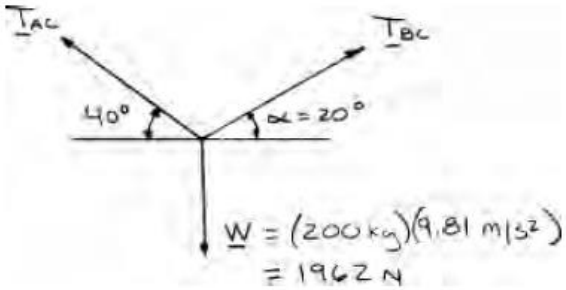


Ques 3. Two cables are tied together at C and are loaded as shown in figure 3. Knowing that α= 20°, determine the tension (a) in cable AC, (b) in cable BC. **(AC=2128.9 N and BC=1735.49 N)**

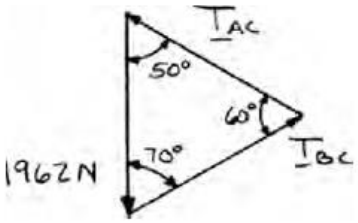


SOLUTION

Free-Body Diagram



Force Triangle

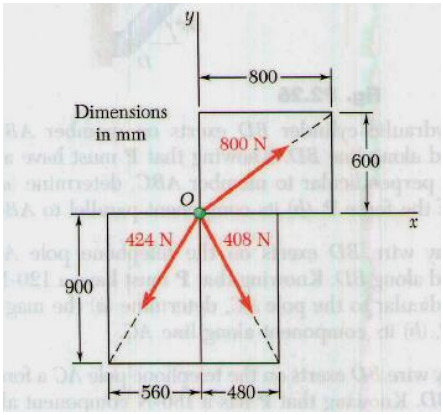


Law of sines: $$\frac{T_{AC}}{\sin 70^\circ} = \frac{T_{BC}}{\sin 50^\circ} = \frac{1962\ \text{N}}{\sin 60^\circ}$$

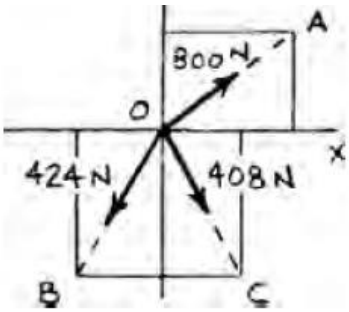
(*a*) $$T_{AC} = \frac{1962\ \text{N}}{\sin 60^\circ}\sin 70^\circ = 2128.9\ \text{N}$$ $T_{AC} = 2.13\ \text{kN}$ ◀

(*b*) $$T_{BC} = \frac{1962\ \text{N}}{\sin 60^\circ}\sin 50^\circ = 1735.49\ \text{N}$$ $T_{BC} = 1.735\ \text{kN}$ ◀

Ques 4 Determine the X and Y components of given forces as shown in figure 4. **(X=608N, and Y=-240N)**



Compute the following distances:



$$OA = \sqrt{(600)^2 + (800)^2}$$
$$= 1000 \text{ mm}$$

$$OB = \sqrt{(560)^2 + (900)^2}$$
$$= 1060 \text{ mm}$$

$$OC = \sqrt{(480)^2 + (900)^2}$$
$$= 1020 \text{ mm}$$

800-N Force:

$$F_x = +(800 \text{ N})\frac{800}{1000} \qquad F_x = +640 \text{ N} \blacktriangleleft$$

$$F_y = +(800 \text{ N})\frac{600}{1000} \qquad F_y = +480 \text{ N} \blacktriangleleft$$

424-N Force:

$$F_x = -(424 \text{ N})\frac{560}{1060} \qquad F_x = -224 \text{ N} \blacktriangleleft$$

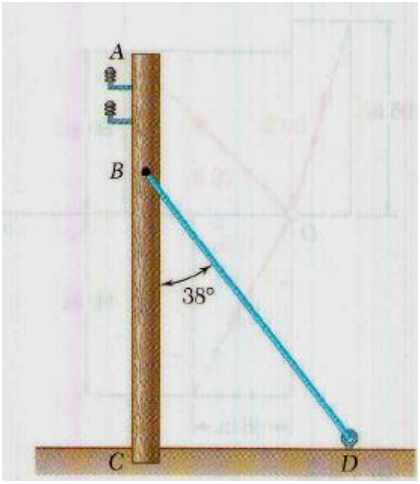
$$F_y = -(424 \text{ N})\frac{900}{1060} \qquad F_y = -360 \text{ N} \blacktriangleleft$$

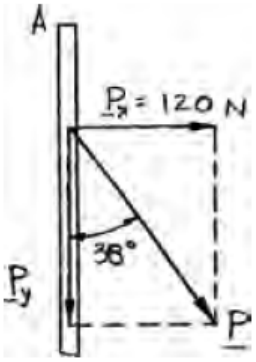
408-N Force:

$$F_x = +(408 \text{ N})\frac{480}{1020} \qquad F_x = +192.0 \text{ N} \blacktriangleleft$$

$$F_y = -(408 \text{ N})\frac{900}{1020} \qquad F_y = -360 \text{ N} \blacktriangleleft$$

Ques 5. The guy wire BD in figure 5 exerts on the telephone pole AC a force P directed along BD. Knowing that P must have a 120-N component perpendicular to the pole AC, determine (a) the magnitude of the force P, (b) its component along line AC. **(P=194.9 N & AC=153.6 N)**





(a)

$$P = \frac{P_x}{\sin 38^\circ}$$

$$= \frac{120\ \text{N}}{\sin 38^\circ}$$

$$= 194.91\ \text{N} \qquad \text{or} \quad P = 194.9\ \text{N} \blacktriangleleft$$

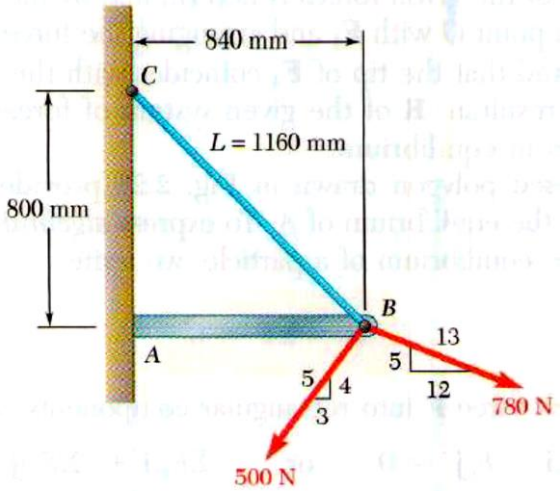
(b)

$$P_y = \frac{P_x}{\tan 38^\circ}$$

$$= \frac{120\ \text{N}}{\tan 38^\circ}$$

$$= 153.59\ \text{N} \qquad \text{or} \quad P_y = 153.6\ \text{N} \blacktriangleleft$$

Ques 6 For the figure 6, determine the required tension in cable BC, if the resultant of three forces exerted at point B is to be vertical (b) the corresponding magnitude of the resultant force **(BC=580 N and R=300 N)**



SOLUTION

$$R_x = \Sigma F_x = -\frac{840}{1160} T_{BC} + \frac{12}{13}(780\text{ N}) - \frac{3}{5}(500\text{ N})$$

$$R_x = -\frac{21}{29} T_{BC} + 420\text{ N} \qquad (1)$$

$$R_y = \Sigma F_y = \frac{800}{1160} T_{BC} - \frac{5}{13}(780\text{ N}) - \frac{4}{5}(500\text{ N})$$

$$R_y = \frac{20}{29} T_{BC} - 700\text{ N} \qquad (2)$$

(*a*) For **R** to be vertical, we must have $R_x = 0$

Set $R_x = 0$ in Eq. (1) $\qquad -\frac{21}{29} T_{BC} + 420\text{ N} = 0 \qquad T_{BC} = 580\text{ N}$ ◀

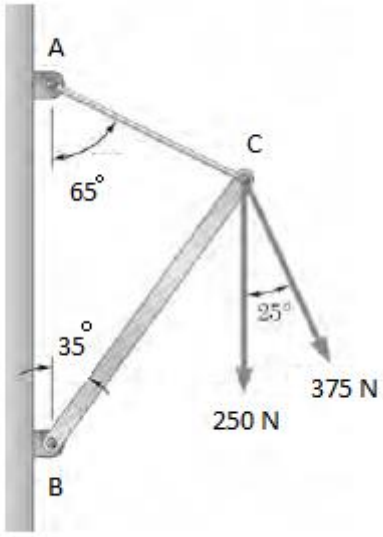
(*b*) Substituting for T_{BC} in Eq. (2):

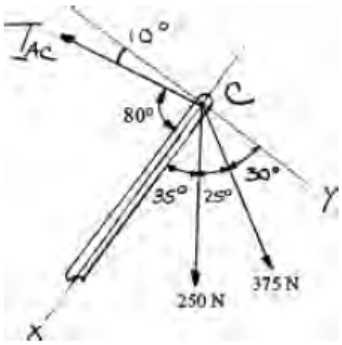
$$R_y = \frac{20}{29}(580\text{ N}) - 700\text{ N}$$

$$R_y = -300\text{ N}$$

$$R = |R_y| = 300\text{ N} \qquad R = 300\text{ N}$$ ◀

Ques 7 Determine (a) the required tension in cable AC, knowing that the resultant of the three forces exerted at point C of boom BC must be directed along BC, (b) the corresponding magnitude of the resultant as shown in Figure 7 **(Tension=475 N and R=475 N).**





Using the x and y axes shown:

$$R_x = \Sigma F_x = T_{AC}\sin 10° + (250\text{ N})\cos 35° + (375\text{ N})\cos 60°$$
$$= T_{AC}\sin 10° + 392.29\text{ N} \qquad (1)$$

$$R_y = \Sigma F_y = (250\text{ N})\sin 35° + (375\text{ N})\sin 60° - T_{AC}\cos 10°$$
$$R_y = 468.15\text{ N} - T_{AC}\cos 10° \qquad (2)$$

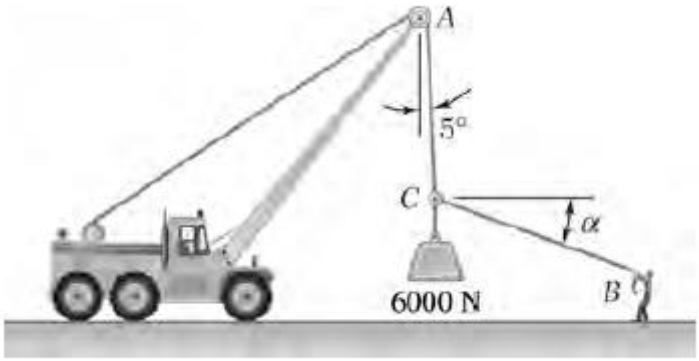
(*a*) Set $R_y = 0$ in Eq. (2):

$$468.15\text{ N} - T_{AC}\cos 10° = 0$$
$$T_{AC} = 475.37\text{ N} \qquad T_{AC} = 475\text{ N} \blacktriangleleft$$

(*b*) Substituting for T_{AC} in Eq. (1):

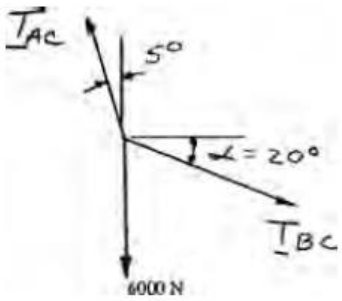
$$R_x = (475.37\text{ N})\sin 10° + 392.29\text{ N}$$
$$= 474.84\text{ N}$$
$$R = R_x \qquad R = 475\text{ N} \blacktriangleleft$$

Ques 8 Knowing that α= 20°, determine the tension (a) in cable AC, (b) in rope BC as shown in figure 8.
(AC=6220 N and BC=577 N)

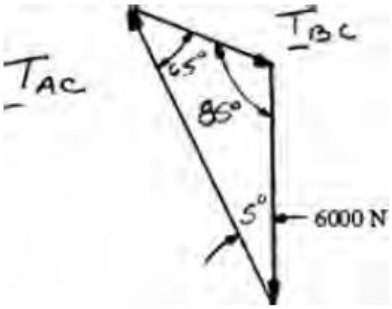


SOLUTION

Free-Body Diagram



Force Triangle

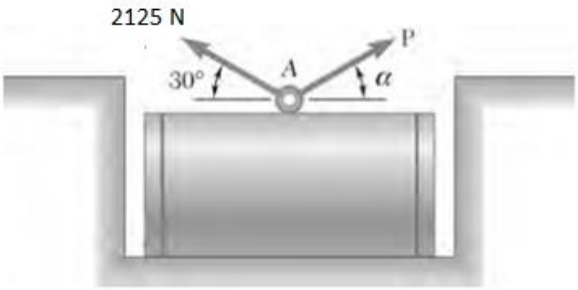


Law of sines: $\frac{T_{AC}}{\sin 110^\circ} = \frac{T_{BC}}{\sin 5^\circ} = \frac{6000\ \text{N}}{\sin 65^\circ}$

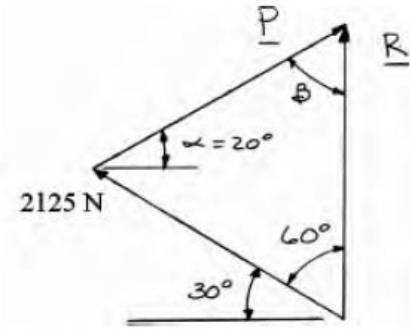
(*a*) $T_{AC} = \frac{6000\ \text{N}}{\sin 65^\circ} \sin 110^\circ$ $T_{AC} = 6220\ \text{N}$ ◀

(*b*) $T_{BC} = \frac{6000\ \text{N}}{\sin 65^\circ} \sin 5^\circ$ $T_{BC} = 577\ \text{N}$ ◀

Ques 9. A Steel Tank is to be positioned in an excavation as given in figure 9. Knowing that the angle α=20°, determine (a) the required magnitude of force P if the resultant R of the two forces applied at A is to be vertical, (b) the corresponding magnitude of R **(P=1958 N and R=1732 N)**



SOLUTION



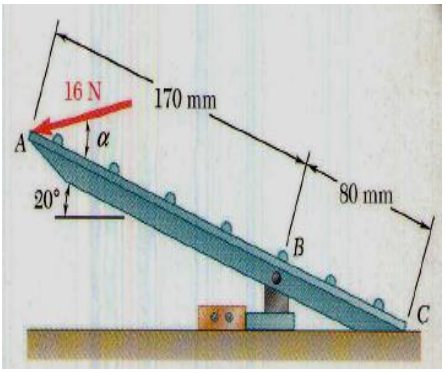
Using the triangle rule and the law of sines:

(*a*)
$$\beta + 50° + 60° = 180°$$
$$\beta = 180° - 50° - 60°$$
$$= 70°$$
$$\frac{2125\ \text{N}}{\sin 70°} = \frac{P}{\sin 60°}$$
$$P = 1958\ \text{N} \blacktriangleleft$$

(*b*)
$$\frac{2125\ \text{N}}{\sin 70°} = \frac{R}{\sin 50°}$$
$$R = 1732\ \text{N} \blacktriangleleft$$

Ques 10 A foot valve for a pneumatic system is hinged at B shown in figure 10. Knowing that α= 28°, determine the moment of the 16-N force about point B by resolving the force into components along ABC and in a direction perpendicular to ABC. **(M=1277 N-mm Anticlockwise)**

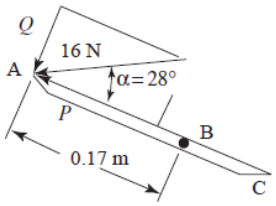
1.



SOLUTION

First resolve the 4-lb force into components **P** and **Q**, where

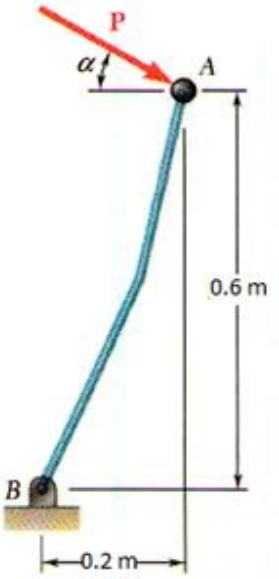
$$Q = (16\ \text{N})\sin 28°$$
$$= 7.5115\ \text{N}$$



Then
$$M_B = r_{A/B} Q$$
$$= (0.17\ \text{m})(7.5115\ \text{N})$$
$$= 1.277\ \text{N}\cdot\text{m}$$

or $\mathbf{M}_B = 1.277\ \text{N}\cdot\text{m}\ \circlearrowleft$ ◀

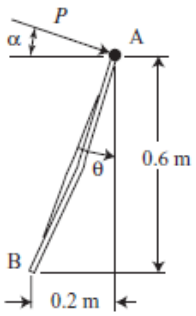
Ques 12 For the shift lever shown as shown in figure 11, determine the magnitude and the direction of the smallest force P that has a 25N-m clockwise moment about B. **(P=39.6 N and α=18.43° in fourth quadrant from x-axis)**



SOLUTION

For **P** to be minimum, it must be perpendicular to the line joining Points A and B. Thus,

$$\alpha = \theta$$
$$= \tan^{-1}\frac{0.2\text{ m}}{0.6\text{ m}}$$
$$= 18.43°$$



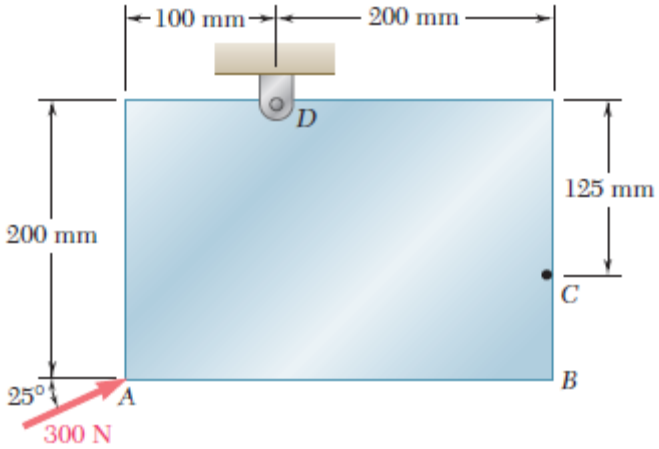
and $$M_B = dP_{\min}$$

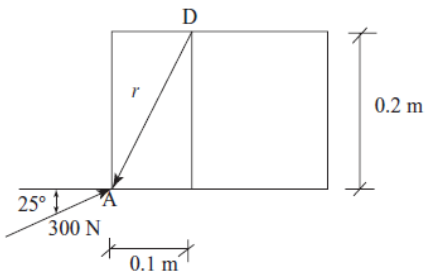
where $$d = r_{A/B}$$
$$= \sqrt{(0.2\text{ m})^2 + (0.6\text{ m})^2}$$
$$= 0.632\text{ m}$$

Then $$P_{\min} = \frac{25\text{ N}\cdot\text{m}}{0.632\text{ m}}$$
$$= 39.6\text{ N}$$

$\mathbf{P}_{\min} = 39.6\text{ N} \measuredangle 18.43°$ ◀

Ques 13. A 300-N force is applied at A as shown. Determine (a) the moment of the 300-N force about D, (b) the magnitude and sense of the horizontal force applied at C that creates the same moment about D, (c) the smallest force applied at C that creates the same moment about D. **(M=41.77 N-m anticlockwise, F_H=334 N and F_S=177 N)**





(*a*)
$$F_x = (300\text{ N})\cos 25°$$
$$= 271.89\text{ N}$$
$$F_y = (300\text{ N})\sin 25°$$
$$= 126.785\text{ N}$$
$$\mathbf{F} = (271.89\text{ N})\mathbf{i} + (126.785\text{ N})\mathbf{j}$$

$$\mathbf{r} = \overrightarrow{DA} = -(0.1\text{ m})\mathbf{i} - (0.2\text{ m})\mathbf{j}$$
$$\mathbf{M}_D = \mathbf{r} \times \mathbf{F}$$

$$\mathbf{M}_D = [-(0.1\text{ m})\mathbf{i} - (0.2\text{ m})\mathbf{j}] \times [(271.89\text{ N})\mathbf{i} + (126.785\text{ N})\mathbf{j}]$$
$$= -(12.6785\text{ N}\cdot\text{m})\mathbf{k} + (54.378\text{ N}\cdot\text{m})\mathbf{k}$$
$$= (41.700\text{ N}\cdot\text{m})\mathbf{k}$$

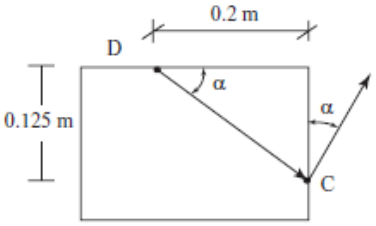
$$\mathbf{M}_D = 41.7\text{ N}\cdot\text{m}\,\circlearrowleft \blacktriangleleft$$

(*b*) Since **C** is horizontal $\mathbf{C} = C\mathbf{i}$

$$\mathbf{r} = \overrightarrow{DC} = (0.2\text{ m})\mathbf{i} - (0.125\text{ m})\mathbf{j}$$
$$\mathbf{M}_D = \mathbf{r} \times C\mathbf{i} = C(0.125\text{ m})\mathbf{k}$$
$$41.7\text{ N}\cdot\text{m} = (0.125\text{ m})(C)$$
$$C = 333.60\text{ N} \qquad C = 334\text{ N} \blacktriangleleft$$

(*c*) The smallest force C must be perpendicular to DC; thus, it forms α with the vertical

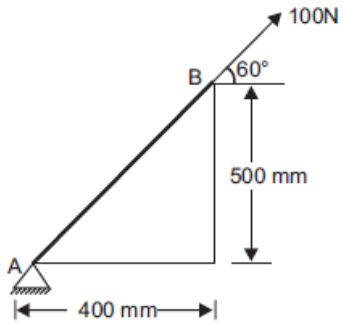
$$\tan\alpha = \frac{0.125\text{ m}}{0.2\text{ m}}$$
$$\alpha = 32.0°$$



$$\mathbf{M}_D = C(DC); \quad DC = \sqrt{(0.2\text{ m})^2 + (0.125\text{ m})^2}$$
$$= 0.23585\text{ m}$$

$$41.70\text{ N}\cdot\text{m} = C(0.23585\text{ m}) \qquad \mathbf{C} = 176.8\text{ N} \angle 58.0° \blacktriangleleft$$

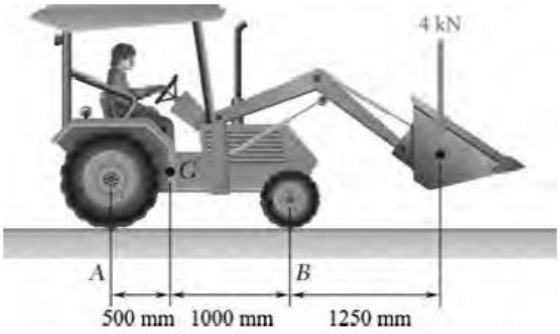
Ques 14 Find the moment of 100 N force acting at B about point A as shown in Figure 13. **(M=9641 N-mm Anti-Clockwise)**



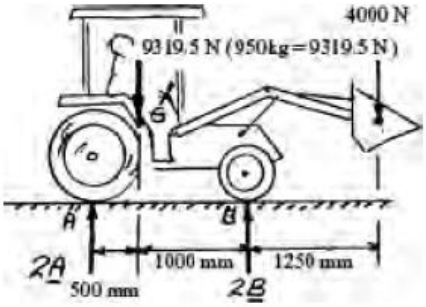
Taking clockwise moment as positive,

$$M_A = 100\cos 60° \times 500 - 100\sin 60° \times 400$$
$$= 25,000 - 34,641.02$$
$$= -9641.02\text{ N-mm}$$
$$= \mathbf{9641.016\text{ N-mm Anticlockwise.}}$$

Ques 15 A tractor of mass 950 kg is used to lift gravel weighing 4 KN. Determine the reaction at each of the front wheel. **($2R_A$=2880 N, $2R_B$=10440 N)**



SOLUTION



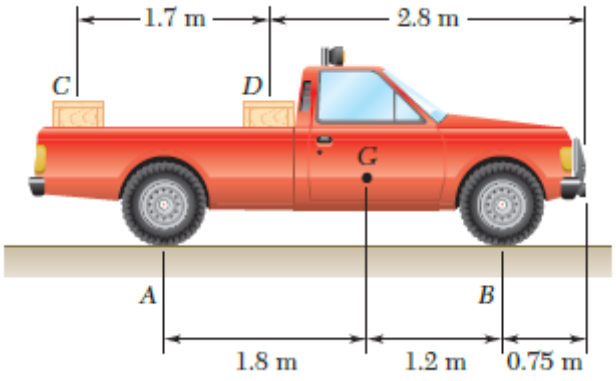
(a) Rear wheels $+\circlearrowleft \Sigma M_B = 0$: $+(9319.5\text{ N})(1000\text{ mm}) - (4000\text{ N})(1250\text{ mm}) - 2A(1500\text{ mm}) = 0$

$A = +1439.83$ N **A = 1440 N ↑ ◀**

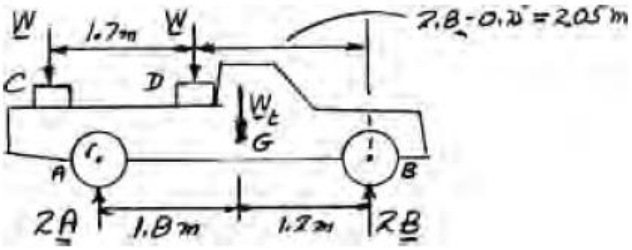
(b) Front wheels $+\circlearrowleft \Sigma M_A$: $-(9319.5\text{ N})(500\text{ mm}) - (4000\text{ N})(2750\text{ mm}) + 2B(1500\text{ mm}) = 0$

$B = +5219.92$ N **B = 5220 N ↑ ◀**

Ques 16. Two crates, each of mass 350 Kg, are placed as shown in the bed of 1400 –kg pickup truck. Determine the reactions at each of the two (a) rear wheels A, (b) front wheels B **(R_A=6.07 KN and R_B=4.23 KN)**



Free-Body Diagram:



$$W = (350\text{ kg})(9.81\text{ m/s}^2) = 3.434\text{ kN}$$

$$W_t = (1400\text{ kg})(9.81\text{ m/s}^2) = 13.734\text{ kN}$$

(*a*) Rear wheels $\overset{+}{\circlearrowleft}\Sigma M_B = 0$: $W(1.7\text{ m} + 2.05\text{ m}) + W(2.05\text{ m}) + W_t(1.2\text{ m}) - 2A(3\text{ m}) = 0$

$$(3.434\text{ kN})(3.75\text{ m}) + (3.434\text{ kN})(2.05\text{ m}) + (13.734\text{ kN})(1.2\text{ m}) - 2A(3\text{ m}) = \mathbf{0}$$

$$A = +6.0663\text{ kN} \qquad \mathbf{A} = 6.07\text{ kN} \uparrow \blacktriangleleft$$

(*b*) Front wheels $+\uparrow \Sigma F_y = 0$: $-W - W - W_t + 2A + 2B = 0$

$$-3.434\text{ kN} - 3.434\text{ kN} - 13.734\text{ kN} + 2(6.0663\text{ kN}) + 2B = 0$$

$$B = +4.2347\text{ kN} \qquad \mathbf{B} = 4.23\text{ kN} \uparrow \blacktriangleleft$$