4–142. Replace the distributed loading with an equivalent resultant force, and specify its location on the beam measured from point $A$. 

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**Loading:** The distributed loading can be divided into four parts as shown in Fig. $a$. The magnitude and location of the resultant force of each part acting on the beam are also indicated in Fig. $a$. 

**Resultants:** Equating the sum of the forces along the $y$ axis of Figs. $a$ and $b$, 

$$ \sum F_y = \sum \frac{1}{2} \left( 15(3) + \frac{1}{2}(5(3)) + 10(3) + \frac{1}{2}(10)(3) \right) = 75 \text{ kN}$$  

**Ans.**

If we equate the moments of $F_R$, Fig. $b$, to the sum of the moment of the forces in Fig. $a$ about point $A$, 

$$ \sum (M_R)_A = \sum M_A = \frac{1}{2} \left( 15(3)(1) - \frac{1}{2}(5)(3)(1) - 10(3)(1.5) - \frac{1}{2}(10)(3)(4) \right)$$  

$$ \sum = 1.20 \text{ m}$$  

**Ans.**
4–143. Replace the distributed loading with an equivalent resultant force, and specify its location on the beam measured from point A.

**Loadings:** The distributed loading can be divided into three parts as shown in Fig. a.

**Resultants:** Equating the sum of the forces along the y axis of Figs. a and b,

\[ \sum F_y = 0; \quad F_R = \frac{1}{2}(8)(3) + \frac{1}{2}(4)(3) + 4(3) = 30 \text{ kN} \]

Ans.

If we equate the moments of \( F_R \), Fig. b, to the sum of the moment of the forces in Fig. a about point A,

\[ \sum (M_A)_y = \sum M_A: \quad -30(3) = \frac{1}{2}(8)(3)(2) - \frac{1}{2}(4)(3)(4) - 4(3)(4.5) \]

\[ (2) = 3.4 \text{ m} \]

Ans.
5–13. Determine the horizontal and vertical components of reaction at \( C \) and the tension in the cable \( AB \) for the truss in

**Equations of Equilibrium:** The tension in the cable can be obtained directly by summing moments about point \( C \).

\[ E_M = 0; \quad T_{AB}\cos 30^\circ(2) + T_{AB}\sin 30^\circ(4) - 3(2) - 4(4) = 0 \]
\[ T_{AB} = 5.89 \text{ kN} \quad \text{Ans} \]

\[ -T_{AC} = 0; \quad C_x = 5.89 \cos 30^\circ = 0 \]
\[ C_x = 5.11 \text{ kN} \quad \text{Ans} \]

\[ +T_{EF} = 0; \quad C_y = 5.89 \sin 30^\circ - 3 - 4 = 0 \]
\[ C_y = 4.05 \text{ kN} \quad \text{Ans} \]
5–21. Determine the horizontal and vertical components of reaction at the pin A and the tension developed in cable BC used to support the steel frame.

Equations of Equilibrium: From the free-body diagram of the frame, Fig. a, the tension $T$ of cable $BC$ can be obtained by writing the moment equation of equilibrium about point $A$.

$$\sum M_A = 0; \quad T \left( \frac{3}{5} \right) 30 + T \left( \frac{4}{5} \right) 1 - 60(1) - 30 = 0$$

$$T = \frac{34.62 \text{ kN}}{} = 34.62 \text{ kN}$$

Using this result and writing the force equations of equilibrium along the $x$ and $y$ axes,

$$\sum F_x = 0; \quad A_x - 34.62 \left( \frac{3}{5} \right) = 0$$

$$A_x = 20.77 \text{ kN} = 20.8 \text{ kN}$$

$$\sum F_y = 0; \quad A_y - 60 - 34.62 \left( \frac{4}{5} \right) = 0$$

$$A_y = 87.69 \text{ kN} = 87.7 \text{ kN}$$
5–27. As an airplane’s brakes are applied, the nose wheel exerts two forces on the end of the landing gear as shown. Determine the horizontal and vertical components of reaction at the pin C and the force in strut AB.

**Equations of Equilibrium**: The force in strut AB can be obtained directly by summing moments about point C.

\[ \sum \tau_C = 0; \quad 2(1) - 6(1\tan 20^\circ) + F_{AB}\sin 50^\circ(0.4) - F_{AB}\cos 50^\circ(0.4\tan 20^\circ) = 0 \]

\[ F_{AB} = 0.8637 \text{ kN} = 0.864 \text{ kN} \quad \text{Ans} \]

Using the result \( F_{AB} = 0.8637 \text{ kN} \) and sum forces along x and y axes, we have:

\[ \sum F_x = 0; \quad 0.8637\sin 50^\circ + 2 - C_x = 0 \]

\[ C_x = 2.66 \text{ kN} \quad \text{Ans} \]

\[ \sum F_y = 0; \quad 6 + 0.8637\cos 50^\circ - C_y = 0 \]

\[ C_y = 6.56 \text{ kN} \quad \text{Ans} \]
5–32. The jib crane is supported by a pin at C and rod AB. If the load has a mass of 2 Mg with its center of mass located at G, determine the horizontal and vertical components of reaction at the pin C and the force developed in rod AB on the crane when $x = 5$ m.

Equations of Equilibrium: Realizing that rod AB is a two-force member, it will exert a force $F_{AB}$ directed along its axis on the beam, as shown on the free-body diagram in Fig. 6. From the free-body diagram, $F_{AB}$ can be obtained by writing the moment equation of equilibrium about point C.

$$\sum M_C = 0; \quad F_{AB} \left( \frac{3}{5} \right) (4) + F_{AB} \left( \frac{4}{5} \right) (0.2) - 2000 (9.81)(5) = 0$$

$$F_{AB} = 38320.31 \text{ N} = 38.3 \text{ kN} \quad \text{Ans.}$$

Using the above result and writing the force equations of equilibrium along the x and y axes.

$$\sum F_x = 0; \quad C_x - 38320.31 \left( \frac{4}{5} \right) = 0$$

$$C_x = 30656.25 \text{ N} = 30.7 \text{ kN} \quad \text{Ans.}$$

$$\sum F_y = 0; \quad 38320.31 \left( \frac{3}{5} \right) - 2000 (9.81) - C_y = 0$$

$$C_y = 3372.19 \text{ N} = 3.4 \text{ kN} \quad \text{Ans.}$$
5–42. Determine the support reactions of roller $A$ and the smooth collar $B$ on the rod. The collar is fixed to the rod $AB$, but is allowed to slide along rod $CD$.

5–42. Determine the support reactions of roller $A$ and the smooth collar $B$ on the rod. The collar is fixed to the rod $AB$, but is allowed to slide along rod $CD$.

Equations of Equilibrium: From the free-body diagram of the rod. Fig. 6, $N_B$ can be obtained by writing the force equation of equilibrium along the axis.

\[
\sum F_x = 0: \quad N_B \sin 45^\circ - 900 = 0 \\
N_B = 1272.79 \text{ N} = 1.27 \text{ kN} \quad \text{Ans.}
\]

Using the above result and writing the force equation of equilibrium and the moment equation of equilibrium about point $B$,

\[
\sum F_x = 0: \quad 1272.79 \cos 45^\circ - A_c = 0 \\
A_c = 900 \text{ N} \quad \text{Ans.}
\]

\[
\begin{align*}
\sum M_B &= 0; \\
&= -900(1) + 900(2) \sin 45^\circ - 600 + M_B = 0 \\
M_B &= 227 \text{ N} \cdot \text{m} \quad \text{Ans.}
\end{align*}
\]

5–89. Determine the horizontal and vertical components of reaction at the pin $A$ and the reaction at the roller $B$ required to support the truss. Set $F = 600 \text{ N}$.

5–89. Determine the horizontal and vertical components of reaction at the pin $A$ and the reaction at the roller $B$ required to support the truss. Set $F = 600 \text{ N}$.

Equations of Equilibrium: The normal reaction $N_a$ can be obtained directly by summing moments about point $A$.

\[
\begin{align*}
\sum M_a &= 0; \\
&= 600(6) + 600(4) + 600(2) - N_a \cos 45^\circ (2) = 0 \\
N_a &= 5091.17 \text{ N} = 5.09 \text{ kN} \quad \text{Ans.}
\end{align*}
\]

\[
\begin{align*}
\sum F_x &= 0; \\
&= A_c - 5091.17 \cos 45^\circ = 0 \\
A_c &= 3600 \text{ N} = 3.60 \text{ kN} \quad \text{Ans.}
\end{align*}
\]

\[
\begin{align*}
\sum F_y &= 0; \\
&= 5091.17 \sin 45^\circ - 3(600) - A_y = 0 \\
A_y &= 1800 \text{ N} = 1.80 \text{ kN} \quad \text{Ans.}
\end{align*}
\]