7.53. Draw the shear and moment diagrams for the beam ABCDE. All pulleys have a radius of 1 ft. Neglect the weight of the beam and pulley arrangement. The load weighs 500 lb.

Support Reactions: From FBD (a).

\[ \sum M = 0; \quad E_x (15) - 500 (7) = 0 \quad E_x = 333.33 \text{ lb} \]
\[ \sum F_y = 0; \quad A_y + 333.33 - 500 = 0 \quad A_y = 166.67 \text{ lb} \]

Shear and Moment Diagrams: The load on the pulley at D can be replaced by equivalent force and couple moment at D as shown on FBD (b).
7-54. Draw the shear and moment diagrams for the beam.

\[ 7 \text{kN} \quad 12 \text{kN} \cdot \text{m} \]

\[ 2 \text{m} \quad 2 \text{m} \quad 4 \text{m} \]

\[ \sum M_b = 0; \quad \sum F_y = 0 \]

\[ F_c = \frac{7 \times 2}{2} - 500 \times 2 = 0 \quad F_c = 625 \text{ N} \]

\[ \sum F_y = 0; \quad A_x + 625 \left( \frac{2}{3} \right) - 500 = 0 \quad A_x = 625 \text{ N} \]

Support Reactions:

\[ F_c = 625 \text{ N} \]

\[ A_x = 625 \text{ N} \]

\[ V(N) = 625 \text{ N} \]

\[ M(N \cdot m) = 750 \text{ N} \cdot \text{m} \]

\[ \sum M_C = 0; \quad 500 \times 3 = 250 \times 2 + F_c \times 2.5 \]

\[ F_c = 625 \text{ N} \]

7-55. Draw the shear and moment diagrams for the beam.

Support Reactions:

\[ \sum M_C = 0; \quad \sum F_y = 0 \]

\[ A_x + 625 \left( \frac{2}{3} \right) - 500 = 0 \quad A_x = 625 \text{ N} \]

\[ V(N) = 625 \text{ N} \]

\[ M(N \cdot m) = 750 \text{ N} \cdot \text{m} \]

\[ \sum M_C = 0; \quad 500 \times 3 = 250 \times 2 + F_c \times 2.5 \]

\[ F_c = 625 \text{ N} \]
7-64. The beam will fail when the maximum moment is \( M_{max} = 30 \text{ kip}\cdot\text{ft} \) or the maximum shear is \( V_{max} = 8 \text{ kip} \). Determine the largest distributed load \( w \) the beam will support.

\[
V_{max} = 4w; \quad 8 = 4w
\]
\[
w = 2 \text{ kip/ft}
\]
\[
M_{max} = -6w; \quad -30 = -6w
\]
\[
w = 5 \text{ kip/ft}
\]
Thus, \( w = 2 \text{ kip/ft} \) Ans.

7-65. The beam consists of two segments pin connected at \( B \). Draw the shear and moment diagrams for the beam.

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12.19. The beam has the rectangular cross section shown. If $P = 15 \text{ kN}$, determine the maximum bending stress in the beam. Sketch the stress distribution acting over the cross section.

**Absolute Maximum Bending Stress:** The maximum moment is $M_{\text{max}} = 0.750 \text{ kN} \cdot \text{m}$ as indicated on moment diagram. Applying the fixture formula

$$
\sigma_{\text{max}} = \frac{M_{\text{max}} c}{I}
$$

$$
= \frac{0.750 \times 10^6 \times 0.05}{\frac{1}{12}(0.05)^4 (0.17)}
$$

$$
= 9.00 \text{ MPa} \quad \text{Ans}
$$
13-18. The supports at \( A \) and \( B \) exert vertical reactions on the wood beam. If the allowable shear stress is \( \tau_{\text{allow}} = 400 \text{ psi} \), determine the intensity \( w \) of the largest distributed load that can be applied to the beam.

*Support Reactions:* As shown on FBD.

*Internal Shear Force:* The maximum shear force occurs at the region \( 0 \leq x < 1 \text{ ft} \) where \( V'_{\text{max}} = 0.750 \text{w} \).

*Section Properties:*

\[
I_{\text{ax}} = \frac{1}{12}(2)(8^3) = 85.333 \text{ in}^4
\]

\[
Q_{\text{max}} = 3\gamma A = 2(150)(2) = 16.0 \text{ in}^3
\]

*Allowable Shear Stress:* Maximum shear stress occurs at the point where the neutral axis pass through the section. Applying shear formula:

\[
\tau_{\text{max}} = \frac{V'_{\text{max}}}{I_{\text{ax}}} \cdot \frac{1}{\frac{0.750 \text{w}}{16.0}} \cdot \frac{400 \text{ in}}{85.333(2)}
\]

\[w = 5689 \text{ lb/ft} = 5.69 \text{ kip/ft} \quad \text{Ans} \]

13-19. Railroad ties must be designed to resist large shear loadings. If the tie is subjected to the 30-kip rail loadings and the gravel bed exerts a distributed reaction as shown, determine the intensity \( w \) for equilibrium, and find the maximum shear stress in the tie.

*Equations of Equilibrium:*

\[+ \sum F_y = 0; \quad 4.50w - 30 - 30 = 0 \quad w = 13.33 \text{ kip/ft} = 13.3 \text{ kip/ft} \quad \text{Ans} \]

*Internal Shear Force:* As shown. \( V_{\text{max}} = 20.0 \text{ kip} \).

*Section Properties:*

\[
I_{\text{ax}} = \frac{1}{12}(4)(8^3) = 144 \text{ in}^4
\]

\[
Q_{\text{max}} = 3\gamma A = 1.5(160)(3) = 36.0 \text{ in}^3
\]

*Maximum Shear Stress:* Maximum shear stress occurs at the point where the neutral axis passes through the section. Applying the shear formula:

\[
\tau_{\text{max}} = \frac{V'_{\text{max}}}{I_{\text{ax}}} \cdot \frac{1}{\frac{20.0(10^3)}{144(8)}} \cdot 625 \text{ psi} \quad \text{Ans} \]