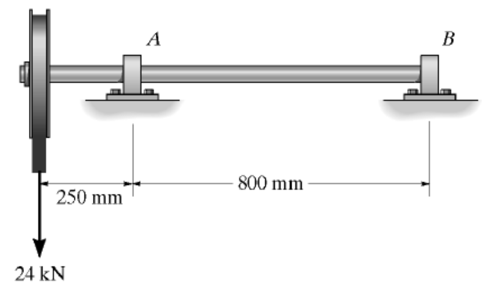
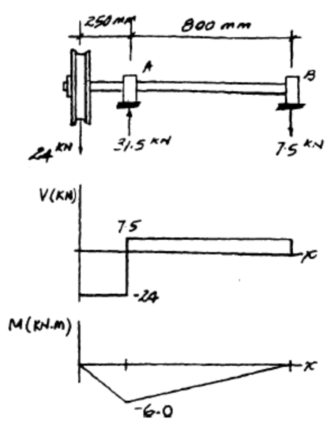
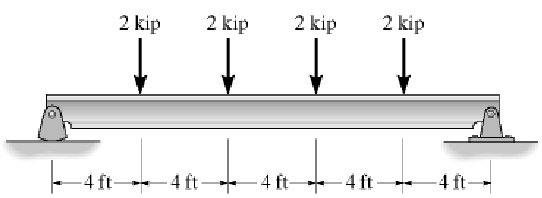
HW 19 SOLUTIONS

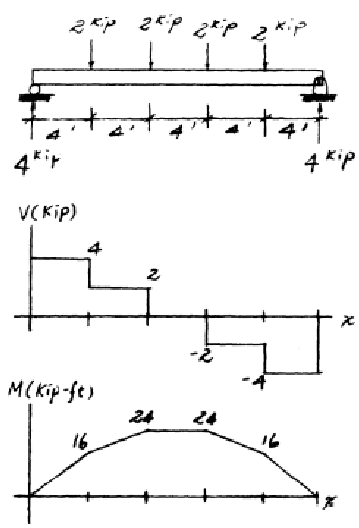
6–1. Draw the shear and moment diagrams for the shaft. The bearings at A and B exert only vertical reactions on the shaft.



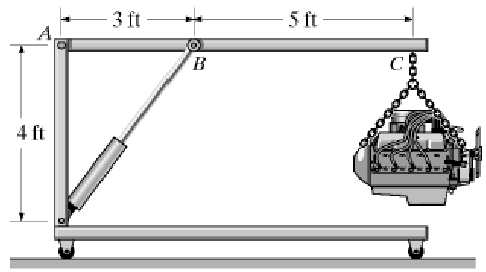


***6–4.** Draw the shear and moment diagrams for the beam.





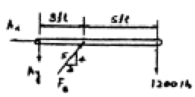
6–10. The engine crane is used to support the engine, which has a weight of 1200 lb. Draw the shear and moment diagrams of the boom ABC when it is in the horizontal position shown.

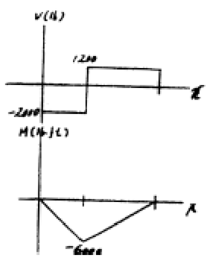


$$\circlearrowleft + \Sigma M_A = 0; \quad \frac{4}{5}F_B(3) - 1200(8) = 0; \quad F_B = 4000 \text{ lb}$$

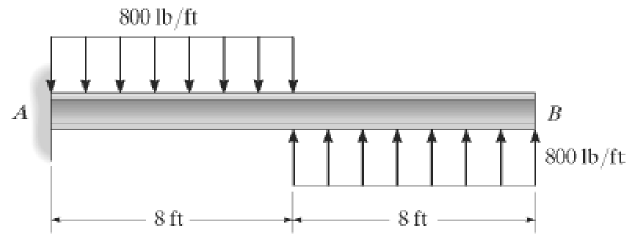
$$+\uparrow \Sigma F_y = 0; \quad -A_y + \frac{4}{5}(4000) - 1200 = 0; \quad A_y = 2000 \text{ lb}$$

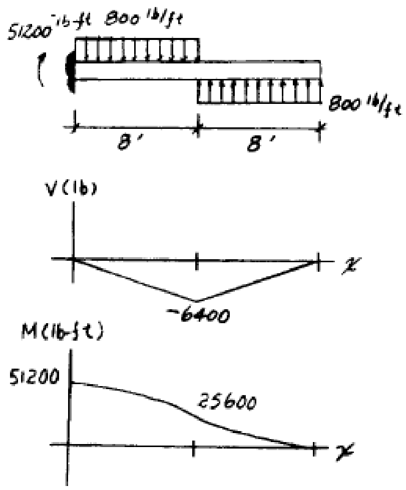
$$\underset{\leftarrow}{+} \Sigma F_x = 0; \quad A_x - \frac{3}{5}(4000) = 0; \quad A_x = 2400 \text{ lb}$$



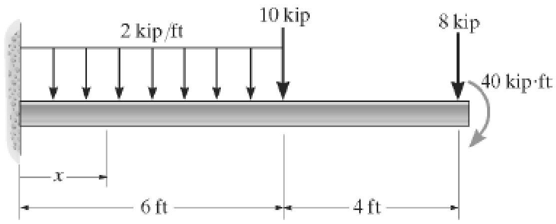


***6–16.** Draw the shear and moment diagrams for the beam.





***6–20.** Draw the shear and moment diagrams for the beam, and determine the shear and moment throughout the beam as functions of x.



Support Reactions: As shown on FBD.
Shear and Moment Function:

For $0 \le x < 6$ ft:

$+\uparrow \Sigma F_y = 0; \quad 30.0 - 2x - V = 0$

$V = \{30.0 - 2x\}$ kip **Ans**

$\curvearrowleft + \Sigma M_{NA} = 0; \quad M + 216 + 2x\left(\frac{x}{2}\right) - 30.0x = 0$

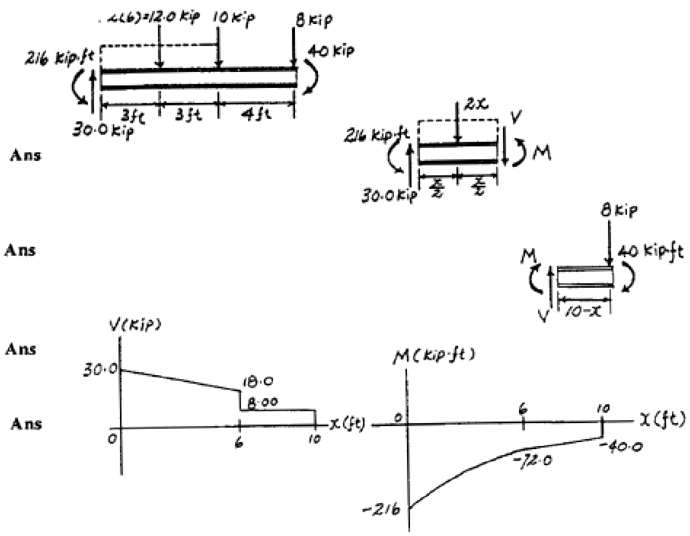
$M = \{-x^2 + 30.0x - 216\}$ kip · ft **Ans**

For $6 \text{ ft} < x \le 10$ ft:

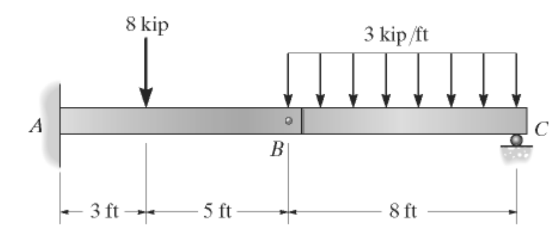
$+\uparrow \Sigma F_y = 0; \quad V - 8 = 0 \quad V = 8.00$ kip **Ans**

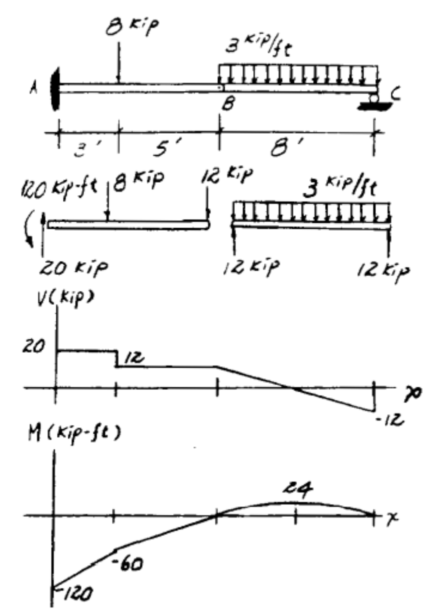
$\curvearrowleft + \Sigma M_{NA} = 0; \quad -M - 8(10 - x) - 40 = 0$

$M = \{8.00x - 120\}$ kip · ft **Ans**

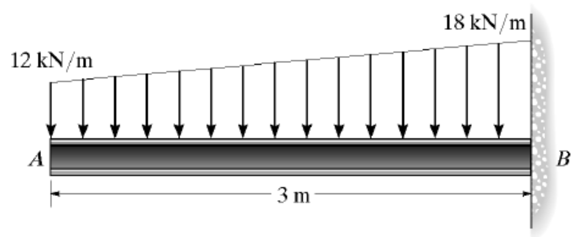


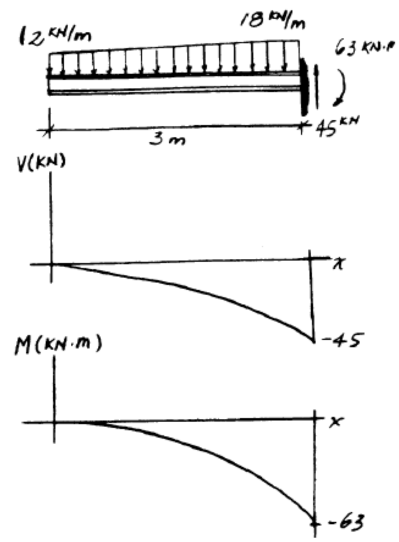
6–25. Draw the shear and moment diagrams for the beam. The two segments are joined together at B.



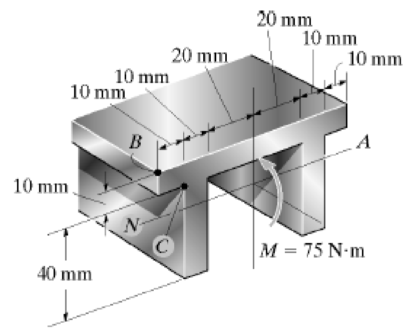


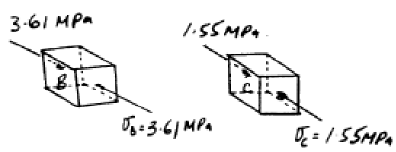
6–38. Draw the shear and moment diagrams for the beam.





6–51. The aluminum machine part is subjected to a moment of $M = 75\ \text{N}\cdot\text{m}$. Determine the bending stress created at points B and C on the cross section. Sketch the results on a volume element located at each of these points.





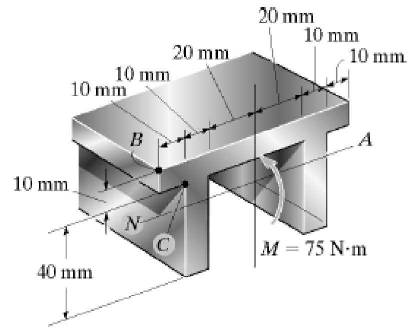
$$\bar{y} = \frac{0.005(0.08)(0.01) + 2[0.03(0.04)(0.01)]}{0.08(0.01) + 2(0.04)(0.01)} = 0.0175\ \text{m}$$

$$I = \frac{1}{12}(0.08)(0.01^3) + 0.08(0.01)(0.0125^2)$$
$$+ 2[\frac{1}{12}(0.01)(0.04^3) + 0.01(0.04)(0.0125^2)] = 0.3633(10^{-6})\ \text{m}^4$$

$$\sigma_B = \frac{Mc}{I} = \frac{75(0.0175)}{0.3633(10^{-6})} = 3.61\ \text{MPa} \qquad \textbf{Ans}$$

$$\sigma_C = \frac{My}{I} = \frac{75(0.0175 - 0.01)}{0.3633(10^{-6})} = 1.55\ \text{MPa} \qquad \textbf{Ans}$$

***6–52.** The aluminum machine part is subjected to a moment of $M = 75\ \mathrm{N \cdot m}$. Determine the maximum tensile and compressive bending stresses in the part.



$$\bar{y} = \frac{0.005(0.08)(0.01) + 2[0.03(0.04)(0.01)]}{0.08(0.01) + 2(0.04)(0.01)} = 0.0175\ \mathrm{m}$$

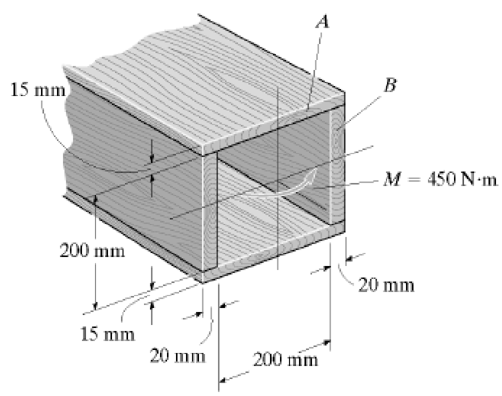
$$I = \frac{1}{12}(0.08)(0.01^3) + 0.08(0.01)(0.0125^2)$$

$$+ 2[\frac{1}{12}(0.01)(0.04^3) + 0.01(0.04)(0.0125^2)] = 0.3633(10^{-6})\ \mathrm{m}^4$$

$$(\sigma_{max})_t = \frac{Mc}{I} = \frac{75(0.050-0.0175)}{0.3633(10^{-6})} = 6.71\ \mathrm{MPa} \quad \textbf{Ans}$$

$$(\sigma_{max})_c = \frac{My}{I} = \frac{75(0.0175)}{0.3633(10^{-6})} = 3.61\ \mathrm{MPa} \quad \textbf{Ans}$$

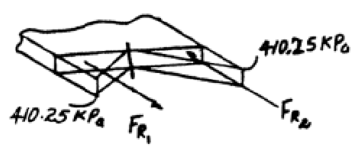
6–53. A beam is constructed from four pieces of wood, glued together as shown. If the moment acting on the cross section is $M = 450\ \mathrm{N \cdot m}$, determine the resultant force the bending stress produces on the top board A and on the side board B.



$$I_y = \frac{1}{12}(0.23)(0.24^3) - \frac{1}{12}(0.2)(0.2^3) = 1.31626\ (10^{-4})\ \mathrm{m}^4$$

$$\sigma_D = \frac{Mx}{I_y} = \frac{450\ (0.12)}{1.31626\ (10^{-4})} = 410.25\ \mathrm{kPa}$$

$$\sigma_C = \frac{Mx}{I_y} = \frac{450\ (0.1)}{1.31626\ (10^{-4})} = 341.88\ \mathrm{kPa}$$



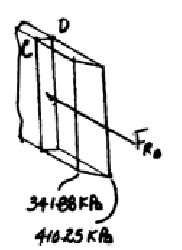
$$F_{R_A} = F_{R_1} - F_{R_2}$$

$$= \frac{1}{2}(410.25)(10^3)(0.12)(0.015) - \frac{1}{2}(410.25)(10^3)(0.12)(0.015)$$

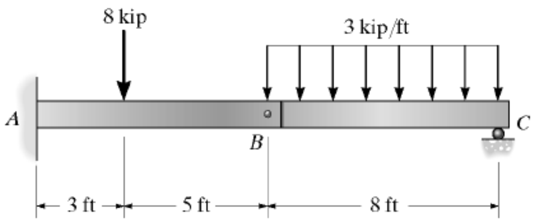
$$= 0 \quad \textbf{Ans}$$

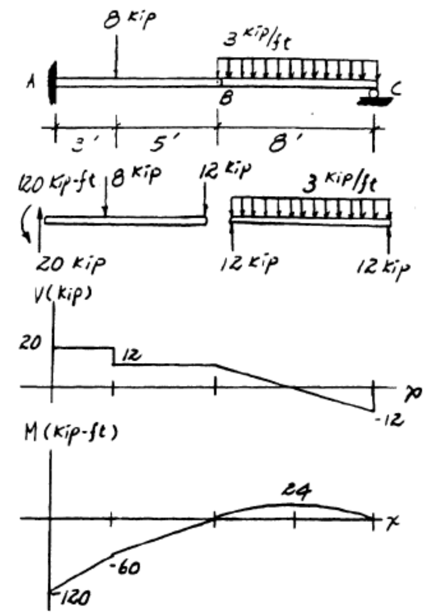
$$F_{R_B} = 341.88\ (10^3)(0.2)(0.02) + \frac{1}{2}(410.25 - 341.88)(10^3)(0.2)(0.02)$$

$$= 1.50\ \mathrm{kN} \quad \textbf{Ans}$$



6–69. Determine the absolute maximum bending stress in the beam in Prob. 6–25. Each segment has a rectangular cross section with a base of 4 in. and height of 8 in.

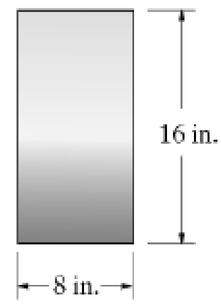


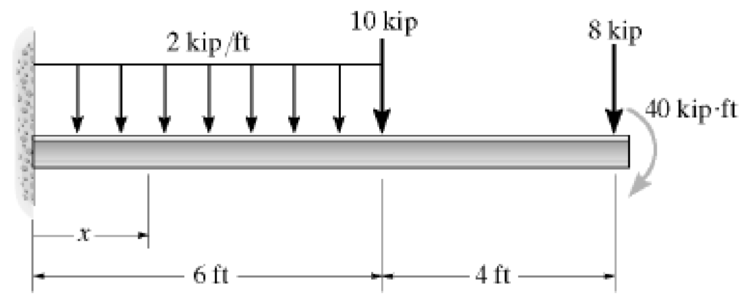


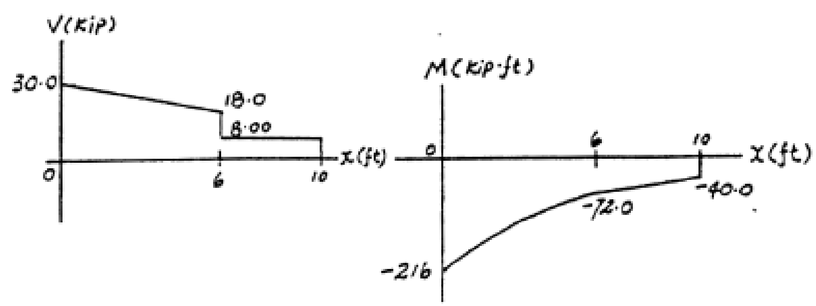
$M_{max} = 120 \text{ kip} \cdot \text{ft}$

$$\sigma_{max} = \frac{Mc}{I} = \frac{120(12)(10^3)(4)}{\frac{1}{12}(4)(8)^3} = 33.8 \text{ ksi} \qquad \textbf{Ans}$$

6–78. If the beam in Prob. 6–20 has a rectangular cross section with a width of 8 in. and a height of 16 in., determine the absolute maximum bending stress in the beam.



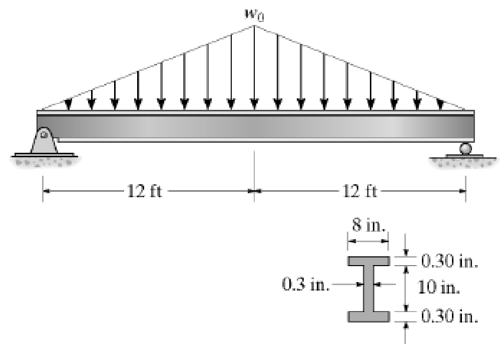




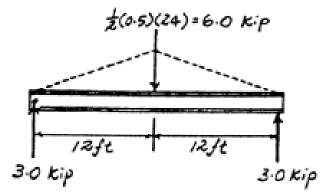
Absolute Maximum Bending Stress : The maximum moment is $M_{max} = 216$ kip · ft as indicated on moment diagram. Applying the flexure formula

$$\sigma_{max} = \frac{M_{max}\,c}{I} = \frac{216(12)(8)}{\frac{1}{12}(8)(16^3)} = 7.59 \text{ ksi} \qquad \textbf{Ans}$$

6–89. The steel beam has the cross-sectional area shown. If $w_0 = 0.5$ kip/ft, determine the maximum bending stress in the beam.



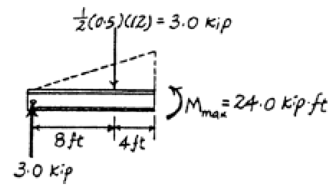
Support Reactions: As shown on FBD.
Internal Moment: The maximum moment occurs at mid span. The maximum moment is determined using the method of sections.



Section Property:

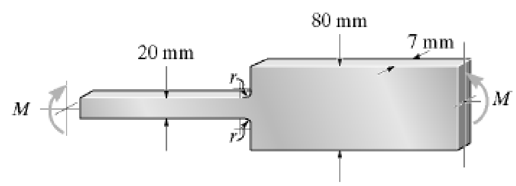
$$I = \frac{1}{12}(8)\left(10.6^3\right) - \frac{1}{12}(7.7)\left(10^3\right) = 152.344 \text{ in}^4$$

Absolute Maximum Bending Stress: The maximum moment is $M_{max} = 24.0$ kip · ft as indicated on the FBD. Applying the flexure formula



$$\sigma_{max} = \frac{M_{max}\, c}{I} = \frac{24.0(12)(5.30)}{152.344} = 10.0 \text{ ksi} \qquad \textbf{Ans}$$

6–146. The bar is subjected to a moment of $M = 17.5$ N · m. If $r = 5$ mm, determine the maximum bending stress in the material.

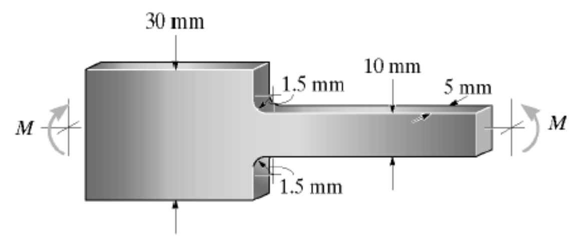


Stress Concentration Factor: From the graph in the text with $\frac{w}{h} = \frac{80}{20} = 4$ and $\frac{r}{h} = \frac{5}{20} = 0.25$, then $K = 1.45$.

Maximum Bending Stress:

$$\sigma_{max} = K\frac{Mc}{I} = 1.45\left[\frac{17.5(0.01)}{\frac{1}{12}(0.007)(0.02^3)}\right] = 54.4 \text{ MPa} \qquad \textbf{Ans}$$

***6–148.** The allowable bending stress for the bar is $\sigma_{allow} = 175$ MPa. Determine the maximum moment M that can be applied to the bar.



Stress Concentration Factor: From the graph in the text with $\frac{w}{h} = \frac{30}{10} = 3$ and $\frac{r}{h} = \frac{1.5}{10} = 0.15$, then $K = 1.6$.

Maximum Bending Stress:

$$\sigma_{max} = \sigma_{allow} = K\frac{Mc}{I}$$

$$175\left(10^6\right) = 1.6\left[\frac{M(0.005)}{\frac{1}{12}(0.005)(0.01^3)}\right]$$

$$M = 9.11\ \text{N}\cdot\text{m}$$ **Ans**