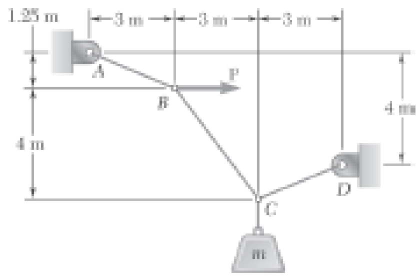
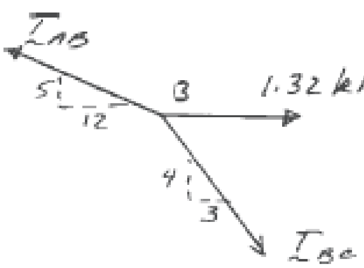


PROBLEM 7.98

A force **P** applied at *B* and a block attached at *C* maintain cable *ABCD* in the position shown. Knowing that the force **P** has a magnitude of 1.32 kN, determine (*a*) the reaction at *A*, (*b*) the required mass *m* of the block, (*c*) the tension in each portion of the cable.

SOLUTION

FBD B:



$\xrightarrow{} \Sigma F_x = 0: \quad -\frac{12}{13}T_{AB} + \frac{3}{5}T_{BC} + 1.32 \text{ kN} = 0$

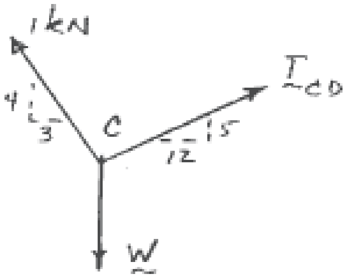
$\uparrow \Sigma F_y = 0: \quad \frac{5}{13}T_{AB} - \frac{4}{5}T_{BC} = 0$

Solving: $T_{AB} = 2.08$ kN, $T_{BC} = 1$ kN

By inspection of *A*,

(*a*) $\mathbf{A} = 2.08 \text{ kN} \measuredangle 22.6°$ ◀

FBD C:



$\xrightarrow{} \Sigma F_x = 0: \quad \frac{12}{13}T_{CD} - \frac{3}{5}(1 \text{ kN}) = 0, \qquad T_{CD} = 0.65 \text{ kN}$

$\uparrow \Sigma F_y = 0: \quad \frac{4}{5}(1 \text{ kN}) + \frac{5}{13}(0.65 \text{ kN}) - w = 0$

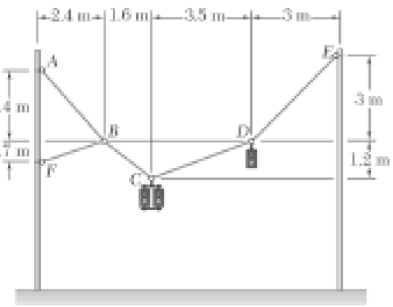
$w = 1.05 \text{ kN}$

(*b*) $m = \frac{w}{g} = \frac{1050 \text{ N}}{9.81 \text{ m/s}^2} = 107.03 \text{ kg}$ $\quad m = 107.0 \text{ kg}$ ◀

(*c*) From above $\quad T_{AB} = 2.08 \text{ kN}$ ◀

$T_{BC} = 1.000 \text{ kN}$ ◀

$T_{CD} = 650 \text{ N}$ ◀

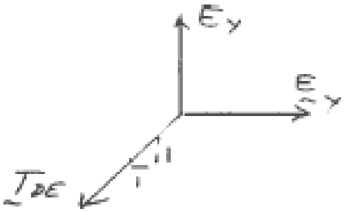


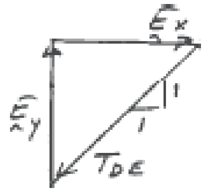
PROBLEM 7.101

Two traffic signals are temporarily suspended from cable *ABCDE*. Knowing that the mass of the signal at *C* is 55 kg, determine (*a*) the mass of the signal at *D*, (*b*) the tension in cable *BF* required to maintain the system in the position shown.

SOLUTION

FBD E:



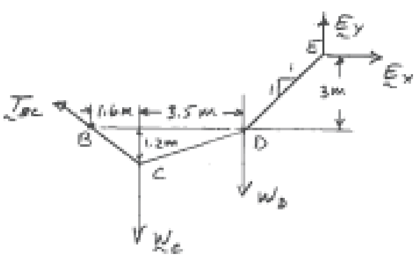


$$\frac{E_x}{1} = \frac{E_y}{1} \qquad E_x = E_y$$

$$\circlearrowleft \Sigma M_C = 0: \quad (6.5\text{ m})E_y - (4.2\text{ m})E_x - (3.5\text{ m})w_D = 0$$

$$2.3E_x = 3.5w_D, \qquad E_x = E_y = \frac{35}{23}w_D$$

FBD CDE:



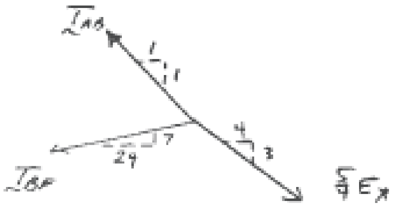
$$\circlearrowleft \Sigma M_B = 0: \quad (8.1\text{ m} - 3\text{ m})\frac{35}{23}w_D - (5.1\text{ m})w_D - (1.6\text{ m})w_C = 0$$

$$w_D = 0.60131\,w_C, \qquad m_D = 0.60131m_C = 33.072\text{ kg}$$

(*a*) $m_D = 33.1\text{ kg}$ ◀

$$\rightarrow \Sigma F_x = 0: \quad -\frac{4}{5}T_{BC} = E_x, \qquad T_{BC} = \frac{5}{4}E_x$$

Point B:



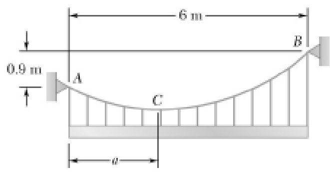
$$\rightarrow \Sigma F_x = 0: \quad \frac{4}{5}\left(\frac{5}{4}E_x\right) - \frac{1}{\sqrt{2}}T_{AB} - \frac{24}{25}T_{BF} = 0$$

$$\uparrow \Sigma F_y = 0: \quad \frac{1}{\sqrt{2}}T_{AB} - \frac{7}{25}T_{BF} + \frac{3}{5}\left(\frac{5}{4}E_x\right) = 0$$

Solving: $\dfrac{31}{25}T_{BF} = \dfrac{1}{4}E_x, \qquad T_{BF} = \dfrac{25}{124}E_x$

$$T_{BF} = \frac{25}{124}\left(\frac{35}{23}w_D\right) = \frac{25}{124}\frac{35}{23}(33.072\text{ kg})(9.81\text{ m/s}^2)$$

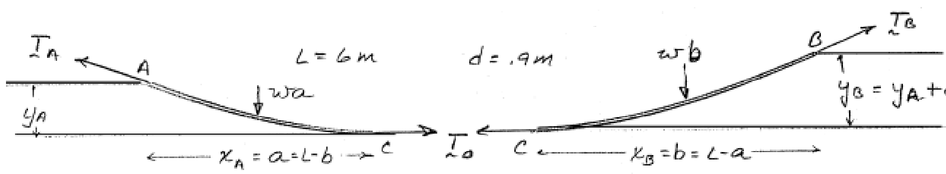
(*b*) $T_{BF} = 99.5\text{ N}$ ◀



PROBLEM 7.112

Chain *AB* supports a horizontal, uniform steel beam having a mass per unit length of 85 kg/m. If the maximum tension in the cable is not to exceed 8 kN, determine (*a*) the horizontal distance *a* from *A* to the lowest point *C* of the chain, (*b*) the approximate length of the chain.

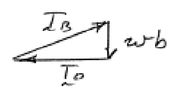
SOLUTION



$\circlearrowleft \Sigma M_A = 0\colon\ y_A T_0 - \frac{a}{2} wa = 0$ $\qquad$ $\circlearrowleft \Sigma M_B = 0\colon\ -y_B T_0 + \frac{b}{2} wb = 0$

$$y_A = \frac{wa^2}{2T_0} \qquad\qquad y_B = \frac{wb^2}{2T_0}$$

$$d = \left(y_B - y_B\right) = \frac{w}{2T_0}\left(b^2 - a^2\right)$$



But $\qquad T_0 = \sqrt{T_B^2 - (wb)^2} = \sqrt{T_{\max}^2 - (wb)^2}$

$$\therefore \quad (2d)^2\left[T_{\max}^2 - (wb)^2\right] = w^2\left(b^2 - a^2\right)^2 = L^2 w^2\left(4b^2 - 4Lb + L^2\right)$$

or $\qquad 4\left(L^2 + d^2\right)b^2 - 4L^3 b + \left(L^4 - 4d^2 \frac{T_{\max}^2}{w^2}\right) = 0$

Using $\qquad L = 6\text{ m}, \quad d = 0.9\text{ m}, \quad T_{\max} = 8\text{ kN}, \quad w = (85\text{ kg/m})\left(9.81\text{ m/s}^2\right) = 833.85\text{ N/m}$

yields $\qquad b = (2.934 \pm 1.353)\text{m} \qquad b = 4.287\text{ m} \qquad (\text{since } b > 3\text{ m})$

(*a*) $\qquad a = 6\text{ m} - b = 1.713\text{ m}$ ◀

PROBLEM 7.112 CONTINUED

$$T_0 = \sqrt{T_{\max}^2 - (wb)^2} = 7156.9\text{ N}$$

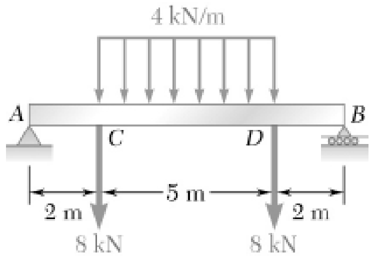
$$\frac{y_A}{x_A} = \frac{wa}{2T_0} = 0.09979 \qquad \frac{y_B}{x_B} = \frac{wb}{2T_0} = 0.24974$$

$$l = s_A + s_B = a\left[1 + \frac{2}{3}\left(\frac{y_A}{x_A}\right)^2 + \cdots\right] + b\left[1 + \frac{2}{3}\left(\frac{y_B}{x_B}\right)^2 + \cdots\right]$$

$$= (1.713\text{ m})\left[1 + \frac{2}{3}(0.09979)^2\right] + (4.287\text{ m})\left[1 + \frac{2}{3}(0.24974)^2\right] = 6.19\text{ m}$$

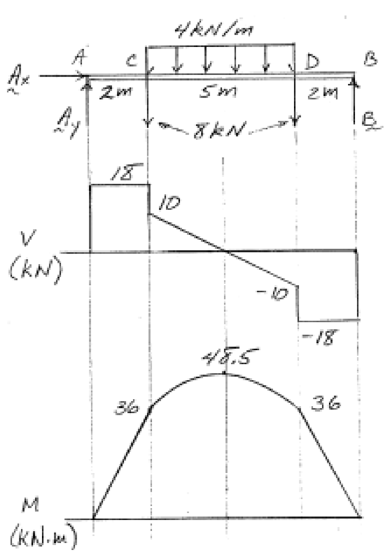
(*b*) $\qquad l = 6.19\text{ m}$ ◀

PROBLEM 7.39



For the beam and loading shown, (*a*) draw the shear and bending-moment diagrams, (*b*) determine the maximum absolute values of the shear and bending moment.

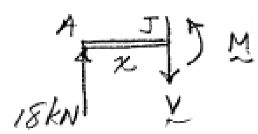
SOLUTION



(*a*) By symmetry:

$$A_y = B = 8\text{ kN} + \frac{1}{2}(4\text{ kN/m})(5\text{ m}) \qquad \mathbf{A}_y = \mathbf{B} = 18\text{ kN}\uparrow$$

Along AC:

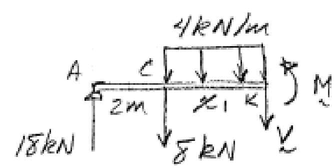


$$+\uparrow \Sigma F_y = 0{:}\ 18\text{ kN} - V = 0 \qquad V = 18\text{ kN}$$

$$+\circlearrowleft \Sigma M_J = 0{:}\ M - x(18\text{ kN}) \qquad M = (18\text{ kN})x$$

$$M = 36\text{ kN}\cdot\text{m at } C\ (x = 2\text{ m})$$

Along CD:



$$+\uparrow \Sigma F_y = 0{:}\ 18\text{ kN} - 8\text{ kN} - (4\text{ kN/m})x_1 - V = 0$$

$$V = 10\text{ kN} - (4\text{ kN/m})x_1$$

$$V = 0 \text{ at } x_1 = 2.5\text{ m (at center)}$$

$$+\circlearrowleft \Sigma M_K = 0{:}\ M + \frac{x_1}{2}(4\text{ kN/m})x_1 + (8\text{ kN})x_1 - (2\text{ m} + x_1)(18\text{ kN}) = 0$$

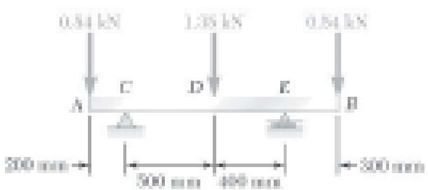
$$M = 36\text{ kN}\cdot\text{m} + (10\text{ kN/m})x_1 - (2\text{ kN/m})x_1^2$$

$$M = 48.5\text{ kN}\cdot\text{m at } x_1 = 2.5\text{ m}$$

Complete diagram by symmetry

(*b*) From diagrams: $|V|_{max} = 18.00\text{ kN on } AC \text{ and } DB$ ◀

$|M|_{max} = 48.5\text{ kN}\cdot\text{m at center}$ ◀

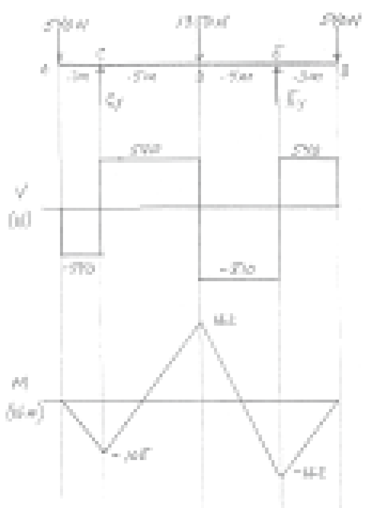


PROBLEM 7.35

For the beam and loading shown, (*a*) draw the shear and bending-moment diagrams, (*b*) determine the maximum absolute values of the shear and bending moment.

SOLUTION

(*a*)



FBD Beam: $\circlearrowleft \Sigma M_E = 0$:

$$(1.1\text{ m})(540\text{ N}) - (0.9\text{ m})C_y + (0.4\text{ m})(1350\text{ N}) - (0.3\text{ m})(540\text{ N}) = 0$$

$$\mathbf{C}_y = 1080\text{ N} \uparrow$$

$$\uparrow \Sigma F_y = 0: \quad -540\text{ N} + 1080\text{ N} - 1350\text{ N}$$

$$-540\text{ N} + E_y = 0 \qquad \mathbf{E}_y = 1350\text{ N} \uparrow$$

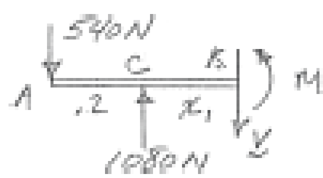
Along AC:

$$\uparrow \Sigma F_y = 0: \quad -540\text{ N} - V = 0$$

$$V = -540\text{ N}$$

$$\circlearrowleft \Sigma M_J = 0: \quad x(540\text{ N}) + M = 0 \qquad M = -(540\text{ N})x$$

Along CD:



$$\uparrow \Sigma F_y = 0: \quad -540\text{ N} + 1080\text{ N} - V = 0 \qquad V = 540\text{ N}$$

$$\circlearrowleft \Sigma M_K = 0: \quad M + (0.2\text{ m} + x_1)(540\text{ N}) - x_1(1080\text{ N}) = 0$$

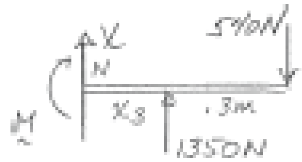
$$M = -108\text{ N}\cdot\text{m} + (540\text{ N})x_1$$

$$M = 162\text{ N}\cdot\text{m at } D \ (x_1 = 0.5\text{ m})$$

continued

PROBLEM 7.35 CONTINUED

Along DE:



$+\uparrow \Sigma F_y = 0$: $V + 1350\text{ N} - 540\text{ N} = 0$ $\qquad V = -810\text{ N}$

$+\circlearrowleft \Sigma M_N = 0$: $M + (x_3 + 0.3\text{ m})(540\text{ N}) - x_3(1350\text{ N}) = 0$

$$M = -162\text{ N}\cdot\text{m} + (810\text{ N})x_3$$

$$M = 162\text{ N}\cdot\text{m at } D\ (x_3 = 0.4)$$

Along EB:

$+\uparrow \Sigma F_y = 0$: $V - 540\text{ N} = 0$ $\qquad V = 540\text{ N}$

$+\circlearrowleft \Sigma M_L = 0$: $M + x_2(540\text{ N}) = 0$ $\qquad M = -540\text{ N}\,x_2$

$$M = -162\text{ N}\cdot\text{m at } E \quad (x_2 = 0.3\text{ m})$$

(*b*) From diagrams $\qquad |V|_{max} = 810\text{ N on } DE$ ◀

$|M|_{max} = 162.0\text{ N}\cdot\text{m at } D \text{ and } E$ ◀