Answers to Even-Numbered Problems

Chapter 1

1.2 Answers given in problem statement.

1.4 **(a)** $l = 13.90$ m; **(b)** $m = 9.279 \times 10^5$ kg; **(c)** $F = 98.30$ kN; **(d)** $M = 10.39\,\text{kN}\cdot\text{m}$.

1.6 **(a)** $l = 25.4\,\mu$m; **(b)** $m = 53.4$ kg; **(c)** $F = 11.4$ kN; **(d)** $I_{\text{mass}} = 2.60\,\text{N}\cdot\text{m}\cdot\text{s}^2$.

1.8 **(a)** $l = 60.37$ ft; **(b)** $m = 0.2961$ slug; **(c)** $F = 476.6$ lb; **(d)** $M = 7656\,\text{in.}\cdot\text{lb}$.

1.10 **(a)** $l = 60.2$ in.; **(b)** $m = 4.46$ slug; **(c)** $F = 20.1$ lb; **(d)** $M = 291\,\text{in.}\cdot\text{lb}$.

1.12 **(a)** $p = 3.63\,\text{lb/in.}^2$; **(b)** $E = 29.0\times 10^6\,\text{lb/in.}^2$; **(c)** $I_{\text{area}} = 5.65\,\text{in.}^4$; **(d)** I_{mass}=$109\,\text{in.}\cdot\text{lb}\cdot\text{s}^2$.

1.14 $m = 0.115$ kg.

1.16 $g_{\text{theory}} = 9.822\,\text{m/s}^2$.

1.18 $F = 2.02\times 10^{14}$ N.

1.20 $F = 0.5649$ lb.

1.22 **(a)** $\gamma = 65.7\,\text{kN/m}^3$, $\rho = 6.70\times 10^3\,\text{kg/m}^3$; **(b)** $\gamma = 20.9\,\text{kN/m}^3$, $\rho = 2.13\times 10^3\,\text{kg/m}^3$; **(c)** $\gamma = 0.314\,\text{kN/m}^3$, $\rho = 32.0\,\text{kg/m}^3$; **(d)** $\gamma = 21.4\,\text{kN/m}^3$, $\rho = 2.19\times 10^3\,\text{kg/m}^3$.

1.24 $b = 7.087$ in.; $h_1 = 23.62$ in.; $h_2 = 19.69$ in.; $L = 6.562$ ft; $W = 3239$ lb.

1.26 0.217 lb.

1.28 **(a)** $\theta = 0.621$ rad; **(b)** $\theta = 0.0188$ mrad; **(c)** $\theta = 266°$; **(d)** $\theta = 0.0146°$.

Chapter 2

2.2 **(a)** $\vec{R} = 255\,\text{mm}$ @ $36.0°\measuredangle$; **(b)** $\vec{R} = 1.10\,\text{kip}$ @ $-142°\measuredangle$.

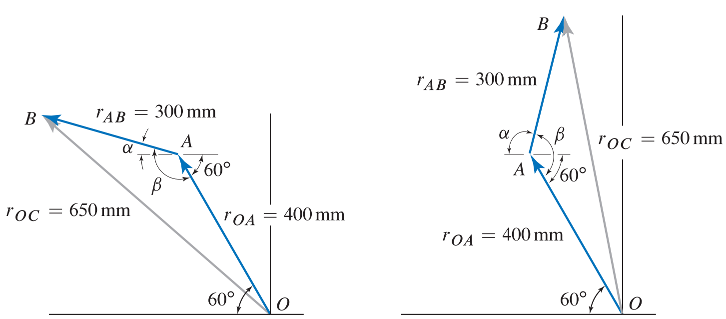
2.4 **(a)** $\vec{R} = 88.39\,\text{N}$ @ $-118.1°\measuredangle$, or if desired, this vector may be stated using a positive angle as $\vec{R} = 88.39\,\text{N}$ @ $241.9°\measuredangle$; **(b)** $\vec{R} = 138.5\,\text{mm}$ @ $14.67°\measuredangle$.

2.6 **(a)** $\vec{R} = 243.6\,\text{lb}$ @ $-34.80°\measuredangle$, or if desired, this vector may be stated using a positive angle as $\vec{R} = 243.6\,\text{lb}$ @ $325.2°\measuredangle$; **(b)** $\vec{R} = 9.129\,\text{in.}$ @ $100.3°\measuredangle$.

2.8 **(a)** $\vec{R} = 6.32\,\text{m}$ @ $71.6°\measuredangle$; **(b)** $\vec{R} = 7.21\,\text{m}$ @ $-56.3°\measuredangle$; **(c)** $\vec{R} = 17.0\,\text{m}^2$ @ $45.0°\measuredangle$; **(d)** $\vec{R} = 1.41$ @ $45.0°\measuredangle$.

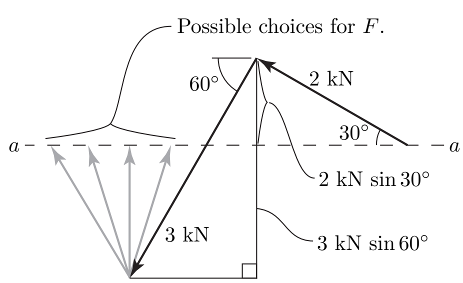
2.10 $F_2 = 1035\,\text{N}$, $R = 267.9\,\text{N}$.

2.12 $\alpha = 16.0°$ or $104°$.



2.14 **(a)** $\vec{R} = 12.14\,\text{kN}$ @ $-19.23°\measuredangle$, or if desired, this vector may be stated using a positive angle as $\vec{R} = 12.14\,\text{kN}$ @ $340.8°\measuredangle$; **(b)** $\vec{R} = 7.134\,\text{in.}$ @ $76.20°\measuredangle$.

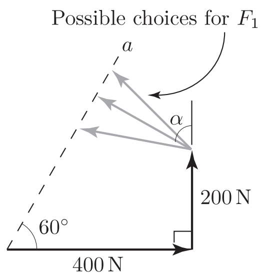
2.16 $F = 1.60\,\text{kN}$, $\theta = 90°$.



2.18 **(a)** 364 N @ 147°$\measuredangle$; **(b)** 239 N @ 257°$\measuredangle$; **(c)** $P = 607$ N; **(d)** $\alpha = 0°$, $P = 304$ N.

2.20 $F_1 = 19.28$ kN, $\alpha = 0°$.

2.22 $F_1 = 246$ N, $\alpha = 60°$.



2.24 **(a)** $|\vec{F}_a| = 25.9$ lb, $|\vec{F}_b| = 96.6$ lb; **(b)** $|\vec{F}_a| = 29.9$ lb, $|\vec{F}_b| = 112$ lb.

2.26 $\vec{F}_a = 164.4$ N @ $-50°\measuredangle$, $\vec{F}_b = 352.5$ N @ 90°$\measuredangle$.

2.28 $\beta = 90°$, $F_{OC'} = 200$ lb.

2.30 $\vec{R} = (-18\,\hat{\imath} + 35\,\hat{\jmath})$ kN.

2.32 $\vec{F} = 1.60\,\hat{\jmath}$ kN.

2.34 **(a)** $\vec{R} = (-304\,\hat{\imath} + 200\,\hat{\jmath})$ N; **(b)** $\vec{R} = (-53.6\,\hat{\imath} - 233\,\hat{\jmath})$ N; **(c)** $P = 607$ N; **(d)** $\alpha = 0°$, $P = 304$ N.

2.36 $\alpha = 60°$, $F_1 = 246$ N, $\vec{F}_1 = (-213\,\hat{\imath} + 123\,\hat{\jmath})$ N.

2.38 **(a)** $\vec{R} = (-15\,\hat{\imath} - 4\,\hat{\jmath})$ kN, $R = 15.52$ kN; **(b)** $\vec{R} = (3\,\hat{\imath} - 28\,\hat{\jmath})$ kN, $R = 28.16$ kN; **(c)** $s = 0.6667$; **(d)** $\hat{R} = 0.1483\,\hat{\imath} + 0.9889\,\hat{\jmath}$.

2.40 **(a)** $\vec{r}_{AB} = (4\,\hat{\imath} - 3\,\hat{\jmath})$ m; **(b)** $\vec{r}_{BA} = (-4\,\hat{\imath} + 3\,\hat{\jmath})$ m; **(c)** $\hat{u}_{AB} = \frac{4}{5}\,\hat{\imath} - \frac{3}{5}\,\hat{\jmath}$; **(d)** $\hat{u}_{BA} = -\frac{4}{5}\,\hat{\imath} + \frac{3}{5}\,\hat{\jmath}$; **(e)** $\vec{F}_{AB} = (9.6\,\hat{\imath} - 7.2\,\hat{\jmath})$ kN; **(f)** $\vec{F}_{BA} = (-9.6\,\hat{\imath} + 7.2\,\hat{\jmath})$ kN.

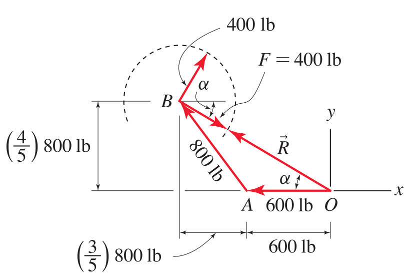
2.42 $\vec{R} = (-93.6\,\hat{\imath} + 541\,\hat{\jmath})$ N, $|\vec{R}| = 549$ N, $\vec{R} = 549$ N @ 99.8°$\measuredangle$.

2.44 $\vec{R} = (-168.9\,\hat{\imath} - 207.0\,\hat{\jmath})$ N $= 267.2$ N @ 230.8°$\measuredangle$, $R = 267.2$ N.

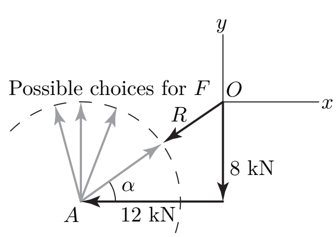
2.46 $\vec{r}_{AB} = (3.235\,\hat{\imath} + 12.07\,\hat{\jmath})$ m, $\vec{r}_{BC} = (2.585\,\hat{\imath} + 1.077\,\hat{\jmath})$ m, $\vec{r}_{CD} = (5.734\,\hat{\imath} - 4.015\,\hat{\jmath})$ m, $\vec{r}_{DE} = (2.236\,\hat{\imath} - 1.118\,\hat{\jmath})$ m, $\vec{r}_{AE} = (13.79\,\hat{\imath} + 8.018\,\hat{\jmath})$ m.

2.48 $F_2/F_1 = 1.50$.

2.50 $\alpha = 30.65°$, $\vec{R} = (-735.9\,\hat{\imath} + 436.1\,\hat{\jmath})$ lb, $R = 855.4$ lb.

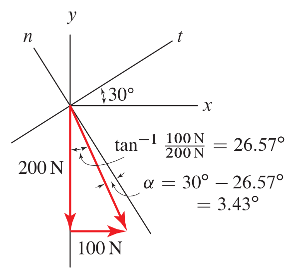


2.52 $\alpha = 33.7°$, $R = 6.42$ kN.



2.54 **(a)** Not safe; **(b)** Safe (the working load multiplier is 70%, determined using linear interpolation); **(c)** Safe (the working load multiplier is 96%, determined using linear interpolation).

2.56 $R_x = 100\,\text{N}$, $R_y = -200\,\text{N}$, $R_t = -13.40\,\text{N}$, $R_n = -223.2\,\text{N}$.



2.58 **(a)** $R_x = 21.61\,\text{N}$, $R_y = 48.30\,\text{N}$; **(b)** $R_t = 8.375\,\text{N}$, $R_n = 52.25\,\text{N}$.

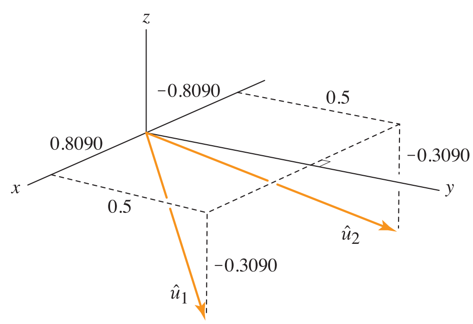
2.60 **(a)** $R_x = -213\,\text{N}$, $R_y = 51.7\,\text{N}$; **(b)** $R_t = -187\,\text{N}$, $R_n = -114\,\text{N}$.

2.62 $\vec{r}_{AB} = (-20\,\hat{\imath} + 48\,\hat{\jmath})\,\text{mm}$, $x_B = 165\,\text{mm}$, $y_B = 48\,\text{mm}$.

2.64 $\vec{r}_{AC} = (-50\,\hat{\imath} + 120\,\hat{\jmath})\,\text{mm}$, $x_C = 135\,\text{mm}$, $y_C = 120\,\text{mm}$.

2.66 $\vec{r}_{OA} = (95\,\hat{\imath} + 56\,\hat{\jmath})\,\text{mm}$, $\vec{r}_{OB} = (68\,\hat{\imath} + 92\,\hat{\jmath})\,\text{mm}$, $\vec{r}_{OC} = (17\,\hat{\imath} + 160\,\hat{\jmath})\,\text{mm}$, $x_B = 68\,\text{mm}$, $y_B = 92\,\text{mm}$.

2.68 $\theta_x = 36°, 144°$.



2.70 With $\theta = \theta_x = \theta_y = \theta_z$, $\theta = 54.74°, 125.3°$, $\cos\theta = \pm\sqrt{\frac{1}{3}} = \pm 0.5774$.

2.72 $\vec{F} = (-59.24\,\hat{\imath} - 162.8\,\hat{\jmath} + 100\,\hat{k})\,\text{N}$, $\vec{Q} = (114.3\,\hat{\imath} + 228.6\,\hat{\jmath} - 157.1\,\hat{k})\,\text{N}$, $\vec{R} = (55.05\,\hat{\imath} + 65.81\,\hat{\jmath} - 57.14\,\hat{k})\,\text{N}$.

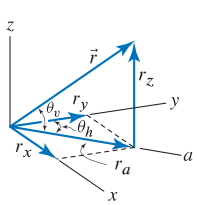
2.74 $\vec{F} = (-4.59\,\hat{\imath} + 26.8\,\hat{\jmath} + 12.6\,\hat{k})\,\text{lb}$, $\vec{Q} = (39.8\,\hat{\imath} + 30.0\,\hat{\jmath} - 33.4\,\hat{k})\,\text{lb}$, $\vec{P} = (50.0\,\hat{\imath} - 70.7\,\hat{\jmath} + 50.0\,\hat{k})\,\text{lb}$, $\vec{R} = (85.2\,\hat{\imath} - 13.9\,\hat{\jmath} + 29.2\,\hat{k})\,\text{lb}$.

2.76 $\vec{P} = (-1.33\,\hat{\imath} + 0.766\,\hat{\jmath} + 1.29\,\hat{k})\,\text{kN}$, $\vec{Q} = (-2.67\,\hat{\imath} + 2.67\,\hat{\jmath} + 1.33\,\hat{k})\,\text{kN}$, $\vec{F} = (2.12\,\hat{\imath} + 1.50\,\hat{\jmath} + 1.50\,\hat{k})\,\text{kN}$, $\vec{R} = (-1.87\,\hat{\imath} + 4.93\,\hat{\jmath} + 4.12\,\hat{k})\,\text{kN}$.

2.78 $\vec{F} = (12.5\,\hat{\imath} - 14.5\,\hat{\jmath} + 16.1\,\hat{k})\,\text{N}$ where $\theta_x = 60°, \theta_y = 125°, \theta_z = 50°$; $\vec{P} = (49.4\,\hat{\imath} + 53.0\,\hat{\jmath} + 19.4\,\hat{k})\,\text{N}$ where $\theta_x = 48.8°, \theta_y = 45°, \theta_z = 75°$; $\vec{R} = (61.9\,\hat{\imath} + 38.5\,\hat{\jmath} + 35.5\,\hat{k})\,\text{N}$ where $\theta_x = 40.3°, \theta_y = 61.6°, \theta_z = 64.0°$.

2.80 4.16 km.

2.82 **(a)** $\theta_x = \pm\cos^{-1}(\sin\theta_h\cos\theta_v)$, $\theta_y = \pm\cos^{-1}(\cos\theta_h\cos\theta_v)$, $\theta_z = \pm\cos^{-1}(\sin\theta_v) = \pm(90° - \theta_v)$; **(b)** $\theta_x = 75.5°, \theta_y = 64.3°, \theta_z = 30°$.



2.84 $\theta_h = 33.7°, \theta_v = 59.0°$.

2.86 $\vec{r}_{AD} = (-80.09\,\hat{\imath} - 150.2\,\hat{\jmath} - 90.00\,\hat{k})\,\text{cm}$.

2.88 $\vec{F}_{BE} = (-44.4\,\hat{\imath} + 77.8\,\hat{\jmath} - 44.4\,\hat{k})\,\text{lb}$, $\vec{F}_{EB} = (44.4\,\hat{\imath} - 77.8\,\hat{\jmath} + 44.4\,\hat{k})\,\text{lb}$.

2.90 $\vec{F}_{BA} = (23.62\,\hat{\imath} - 16.24\,\hat{\jmath} - 8.857\,\hat{k})\,\text{lb}$, $\vec{F}_{BC} = -1500\,\text{lb}\,\hat{\jmath}$.

2.92 $\vec{F}_{BA} = (16.60\,\hat{\imath} - 24.88\,\hat{\jmath} - 2.262\,\hat{k})\,\text{lb}$, $\vec{F}_{BC} = -1500\,\text{lb}\,\hat{\jmath}$.

2.94 $(x_E, y_E, z_E) = (80, 60, 120)\,\text{mm}$, $\vec{F}_{EG} = (-47.1\,\hat{\imath} + 52.9\,\hat{\jmath} + 70.6\,\hat{k})\,\text{N}$.

2.96 $\vec{F}_{CD} = (-2.4\,\hat{\imath} + 1.8\,\hat{k})$ kN, $\vec{F}_{BE} = -5\,\text{kN}\,\hat{k}$.

2.98 $\vec{F}_{CD} = (-0.8208\,\hat{\imath} - 2.255\,\hat{\jmath} + 1.800\,\hat{k})$ kN, $\vec{F}_{BE} = -5\,\text{kN}\,\hat{k}$.

2.100 $\theta_x = \cos^{-1}(\sin\phi\cos\theta)$, $\theta_y = \cos^{-1}(\sin\phi\sin\theta)$, $\theta_z = \phi$.

2.102 **(a)** $F_B/F_A = 1.51$; **(b)** Spokes on side B are more severely loaded; **(c)** Essay-type answer.

2.104 **(a)** 128°; **(b)** $A_\parallel = -4.33$ lb, $A_\perp = 5.50$ lb; **(c)** $\vec{A}_\parallel = (4.04\,\hat{\imath} + 0.578\,\hat{\jmath} - 1.44\,\hat{k})$lb, $\vec{A}_\perp = (1.96\,\hat{\imath} - 2.58\,\hat{\jmath} + 4.44\,\hat{k})$lb.

2.106 **(a)** 145.7°; **(b)** $A_\parallel = -10.73$ N, $A_\perp = 7.335$ N; **(c)** $\vec{A}_\parallel = (1.431\,\hat{\imath} - 3.578\,\hat{\jmath} + 10.02\,\hat{k})$ N, $\vec{A}_\perp = (2.569\,\hat{\imath} + 6.578\,\hat{\jmath} + 1.982\,\hat{k})$ N.

2.108 $d = 5.77$ cm , $\theta = 41.4°$.

2.110 $\alpha = 4.70°$, $\beta = 9.43°$, $a = 12.2$ in., $b = 12.0$ in..

2.112 $F_\parallel = -67.4$ N, $F_\perp = 73.9$ N, The bead slides toward C.

2.114 Answer given in problem statement.

2.116 $F = -1.79$ kip, $\vec{F} = (0.808\,\hat{\imath} + 0.0659\,\hat{\jmath} - 1.60\,\hat{k})$ kip.

2.118 $F = 5.83$ N.

2.120 $F_\parallel = (0.937)F$, $F_\perp = (0.349)F$.

2.122 $W = 45.0$ N.

2.124 **(a)** $F_\parallel = 44.25$ N, $F_\perp = 23.28$ N; **(b)** $F_\parallel = 41.31$ N, $F_\perp = 28.17$ N.

2.126 460.0 lb.

2.128 593.5 lb.

2.130 $\vec{T}_\parallel = (-3.537\,\hat{\imath} + 1.179\,\hat{\jmath} - 1.769\,\hat{k})$ lb, $\vec{T}_\perp = (4.648\,\hat{\imath} + 3.265\,\hat{\jmath} - 7.120\,\hat{k})$ lb, The bead slides toward B.

2.132 $F_\parallel = -1.71$ N, $F_\perp = 60.0$ N, The bead slides toward A.

2.134 86.93 km/h.

2.136 The shortest distance is 209.5 m, The point where the road is closest lies outside of segment CD.

2.138 $v = (1.149)s$.

2.140 51.7 mm.

2.142 12.0 in.

2.144 **(a)** and **(b)** $350\,\hat{k}$ N·mm.

2.146 **(a)** $(-120\,\hat{\imath} - 2\,\hat{\jmath} - 26\,\hat{k})$ mm^2; **(b)** $(120\,\hat{\imath} + 2\,\hat{\jmath} + 26\,\hat{k})$ mm^2; **(c)** Essay-type answer; **(d)** Answer given in problem statement.

2.148 **(a)** $(-118\,\hat{\imath} - 426\,\hat{\jmath} - 360\,\hat{k})$ in.·lb.; **(b)** $(118\,\hat{\imath} + 426\,\hat{\jmath} + 360\,\hat{k})$ in.·lb.; **(c)** The results of Parts (a) and (b) are vectors with equal magnitude but opposite direction; **(d)** Answer given in problem statement.

2.150 Essay-type answer.

2.152 **(a)** Yes; **(b)** $\vec{M}_O = (-19300\,\hat{\imath} + 13600\,\hat{\jmath})$ in.·lb.

2.154 **(a)** Essay-type answer; **(b)** $\hat{u} = 0.192\,\hat{\imath} + 0.192\,\hat{\jmath} + 0.962\,\hat{k}$; **(c)** 364 cm^2.

2.156 0.5147°, The surface is not sufficiently level.

2.158 $\vec{v}_n = (-2.92\,\hat{\imath} - 7.87\,\hat{\jmath} - 6.30\,\hat{k})$ km/s, $\vec{v}_t = (-3.62\,\hat{\imath} - 1.95\,\hat{\jmath} + 4.11\,\hat{k})$ km/s, $|\vec{v}_n| = 10.5$ km/s, $|\vec{v}_t| = 5.82$ km/s.

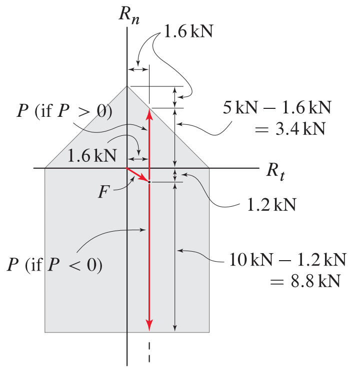
2.160 **(a)** Since $\vec{r}_1 \cdot \vec{r}_{AB} = 0$, the vectors $\vec{r}_1$ and $\vec{r}_{AB}$ are perpendicular; **(b)** $\hat{r}_2 = 0.8920\,\hat{\imath} - 0.03678\,\hat{\jmath} - 0.4506\,\hat{k}$; **(c)** $P_{AB} = 50.55$ N, $P_1 = 281.3$ N, $P_2 = -958.3$ N.

2.162 **(a)** Since $\vec{r}_{AB} \cdot \vec{r}_{CD} = 0$, the vectors $\vec{r}_{AB}$ and $\vec{r}_{CD}$ are perpendicular; **(b)** $\hat{r} = 0.8909\,\hat{\imath} - 0.4483\,\hat{\jmath} - 0.07284\,\hat{k}$; **(c)** $P_{AB} = 412.2$ lb, $P_{CD} = 162.4$ lb, $P_r = -404.6$ lb. **NOTE:** The first printing of this book has an error in the last sentence of the statement for Part (c). The force referenced in the last sentence should be 600 lb (not 50 N). This error is corrected in the second and subsequent printings of the book.

2.164 6.57 mm.

2.166 **(a)** and **(b)** 23.4 N·m.

2.168 $-8.8\,\text{kN} \le P \le 4.6\,\text{kN}$.



2.170 **(a)** $\vec{R} = (-2.29\,\hat{\imath} + 2.72\,\hat{\jmath} - 1.45\,\hat{k})$ kN; **(b)** $\vec{T} = (2.29\,\hat{\imath})$ kN.

2.172 The distance from point A to point B is 3058 ft and the length of the power line is 2796 ft.

2.174 $P_\perp = (-0.970)\,P$, $P_\parallel = (0.243)\,P$.

2.176 1.672°, The surface meets the drainage specification.

2.178 $P_\parallel = 7.66$ kN, $P_\perp = 6.43$ kN, $\vec{P}_\parallel = (-3.48\,\hat{\imath} - 3.48\,\hat{\jmath} - 5.87\,\hat{k})$ kN, $\vec{P}_\perp = (3.48\,\hat{\imath} + 3.48\,\hat{\jmath} - 4.13\,\hat{k})$ kN.

2.180 **(a)** $\theta_x = 125.5°$; **(b)** $\hat{r} = -0.2632\,\hat{\imath} - 0.7291\,\hat{\jmath} + 0.6318\,\hat{k}$; **(c)** $P_r = 12.08$ N.

2.182 **(a)** $\theta_x = 107°$, $\theta_y = 114°$; **(b)** $0.520\,\hat{\imath} + 0.693\,\hat{\jmath} + 0.500\,\hat{k}$ (or $-0.520\,\hat{\imath} - 0.693\,\hat{\jmath} - 0.500\,\hat{k}$).

2.184 900 ft.

2.186 Answers given in problem statement.

Chapter 3

3.2 $T_{AB} = 217.0$ lb (tension), $T_{BC} = 176.9$ lb (tension), $T_{BD} = 200$ lb (tension).

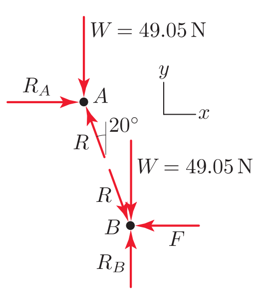
3.4 $T_{AB} = 92.65$ N (tension), $T_{BC} = -54.50$ N (compression), $T_{BD} = 49.05$ N (tension).

3.6 $\alpha = 50°$, $T_{AB} = 128.6$ lb, $T_{BC} = 153.2$ lb, $T_{BD} = 200$ lb.

3.8 $R_C = R_D = 31.8$ lb.

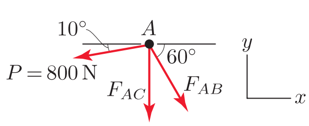
3.10 **(a)** $T_1 = 251$ lb, $R = 141$ lb; **(b)** $T_2 = 149$ lb, $R = 141$ lb.

3.12 **(a)** $F = 17.9$ N, $R_A = 17.9$ N, $R_B = 98.1$ N, $R = 52.2$ N **(b)** The system is in equilibrium and blocks A and B may move with constant velocity, but they will not accelerate. **(c)** The system is not in equilibrium, block B will accelerate to the right, and block A will accelerate downward.



3.14 $T_{AB} = 5.13$ kN, $T_{AC} = 0.340$ kN.

3.16 $F_{AB} = 1580$ N, $F_{AC} = -1500$ N.

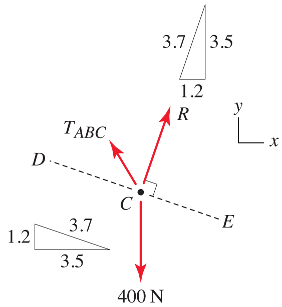


3.18 $T_{AB} = 259.1$ N.

3.20 $T_{AC} = 2.294$ lb.

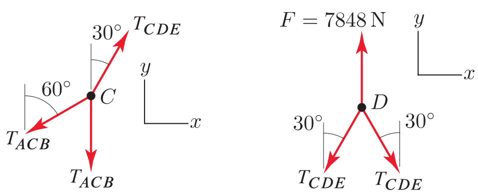
3.22 (**a**) $T_{AB} = 175\,\mathrm{N}$; (**b**) $T_{CD} = T_{CE} = 109\,\mathrm{N}$; (**c**) Essay-type answer.

3.24 $T_{ABC} = 169.8$ N, $R = 268.8$ N.

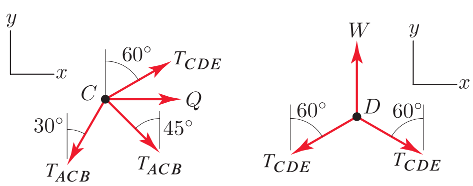


3.26 (**a**) Answer provided in problem description; (**b**) $F = 2T\cos\theta$; (**c**) Essay-type answer.

3.28 $T_{ACB} = 2620\,\mathrm{N}$, $T_{CDE} = 4530\,\mathrm{N}$.



3.30 $m = 547\,\mathrm{kg}$.



3.32 $Q_{max} = 2041$ lb.

3.34 $T_{CD} = 5710\,\mathrm{N}$, $T_{BA} = 3710\,\mathrm{N}$, $T_{CB} = 4290\,\mathrm{N}$, $W = 1140\,\mathrm{N}$.

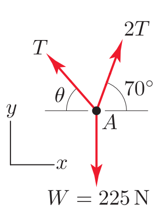
3.36 $W_{max} = 2.4$ kN.

3.38 (**a**) System (a): $T = W$, system (b): $T = \frac{1}{2}W$, system (c): $\frac{1}{2}W$, system (d): $\frac{1}{3}W$, system (e): $\frac{1}{3}W$, system (f): $\frac{1}{4}W$; (**b**) Essay-type answer.

3.40 $W = 218\,\mathrm{lb}$.

3.42 $T_{BH} = 540\,\mathrm{lb}$, $T_{HE} = 540\,\mathrm{lb}$, $T_{BC} = 717\,\mathrm{lb}$, $T_{EF} = 586\,\mathrm{lb}$, $W_A = 322\,\mathrm{lb}$, $W_G = 369\,\mathrm{lb}$, $W_D = 108\,\mathrm{lb}$.

3.44 $\theta = 46.8°$, $T = 86.2\,\mathrm{N}$.

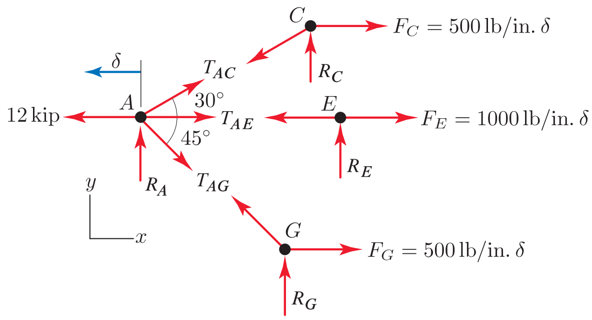


3.46 $W_1 = 11.3\,\mathrm{N}$, $W_2 = 32.6\,\mathrm{N}$.

3.48 $d = 45$ in., $T_{ABC} = 54.17$ lb.

3.50 $\alpha = -30°$; *intermediate answer:* $F_{BD} = \frac{(5\,\mathrm{lb})(\cos 30° + \sin 30°)}{\cos 30° \cos\alpha - \sin 30° \sin\alpha}$.

3.52 $T_{AC} = 3460\,\text{lb}$, $T_{AE} = 6000\,\text{lb}$, $T_{AG} = 4240\,\text{lb}$, $\delta = 6.00\,\text{in.}$

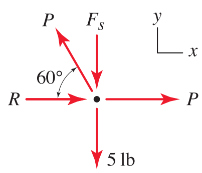


3.54 $\delta_A = 14.72$ mm, $\delta_B = 27.80$ mm.

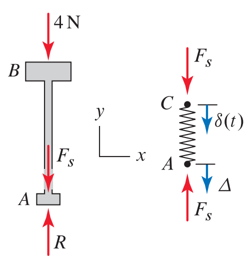
3.56 $\delta_A = 5.2$ in., $\delta_B = 4.9$ in., $\delta_C = 4$ in, $\delta_D = 2.4$ in.

3.58 **(a)** $L_{AB} = 94.3\,\text{cm}$, $L_{AD} = 120\,\text{cm}$; **(b)** $x = 104\,\text{cm}$, $y = 46.7\,\text{cm}$.

3.60 $P = 10.39$ lb, $R = -5.196$ lb.



3.62 **(a)** 10.0 N, 8.00 N; **(b)** 7.00 N, 5.00 N.



3.64 $k = 167\,\text{lb/in.}$, $L_0 = 21.0\,\text{in.}$

3.66 $\delta = 0.587\,\text{in.}$, $F_1 = 128\,\text{lb}$, $F_2 = 345\,\text{lb}$, $F_3 = 128\,\text{lb}$.

3.68 **(a)** $P = 6000$ N, $T_{AB} = 8000$ N; **(b)** $x_A = 229.2$ mm, $y_A = -71.11$ mm.

3.70 $\delta = 3.42\,\text{mm}$.

3.72 **(a)** $d = 95.49$ in., $F_1 = -1082$ lb (compression), $F_2 = 1082$ lb (tension);
(b) $d = 86.40$ in., $F_1 = -3264$ lb (compression), $F_2 = -1736$ lb (compression).

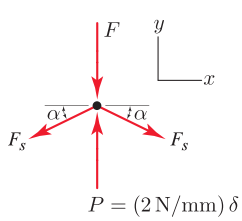
3.74 $\delta_A = 4.355$ mm, $\delta_B = 5.547$ mm, $F_1 = 119.2$ N, $F_2 = -665.6$ N, $F_3 = -609.7$ N.

3.76 **(a)** $\delta = 1.17\,\text{in.}$; **(b)** $\delta = 1.99\,\text{in.}$

3.78 $W = 13.33$ lb.

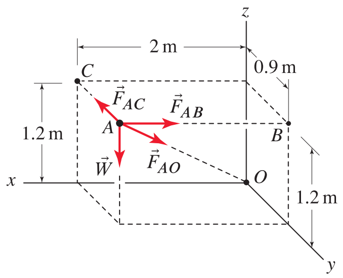
3.80 $\theta = 83.62°$.

3.82 **(a)** $F = -2(2\,\text{N/mm})\dfrac{\sqrt{(5\,\text{mm})^2+(2\,\text{mm}-\delta)^2}-\sqrt{29}\text{mm}}{\sqrt{(5\,\text{mm})^2+(2\,\text{mm}-\delta)^2}}(2\,\text{mm}-\delta) + (0.3\,\text{N/mm})\delta$; **(b)** Answer not provided; **(c)** $F_{\text{max}} = 0.600\,\text{N}$; **(d)** Essay-type answer.



3.84 $F_{\max} = 3.333\,\text{kN}$.

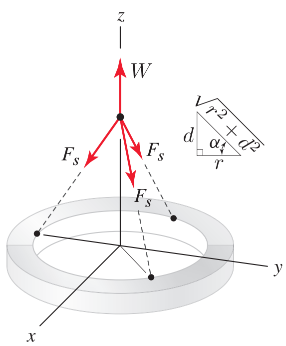
3.86 $m_D = 91.7\,\text{kg}$.



3.88 $W = 500\,\text{N}$.

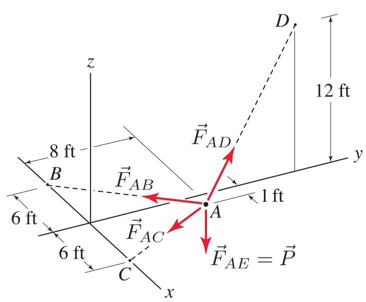
3.90 $T_{AO} = -698.5\,\text{lb}$, $T_{AB} = 833.3\,\text{lb}$, $T_{AC} = 541.7\,\text{lb}$, $T_{AD} = 1000\,\text{lb}$.

3.92 **(a)** $W = 3k\left(1 - \frac{r}{\sqrt{r^2+d^2}}\right)d$; **(b)** $d = 16.9\,\text{in}$.

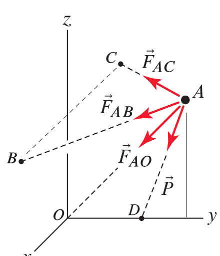


3.94 $P = 533\,\text{lb}$.

3.96 $P = 532\,\text{lb}$.

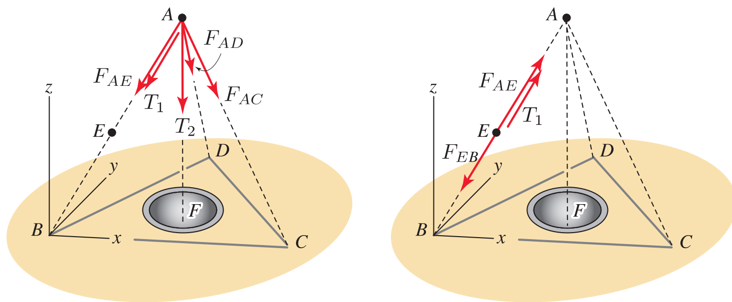


3.98 $P = 1450\,\text{lb}$.



3.100 $T_{AB} = 365.8\,\text{lb}$, $T_{BD} = 292.3\,\text{lb}$, $T_{BE} = 339.8\,\text{lb}$, $T_{BH} = 1200\,\text{lb}$.

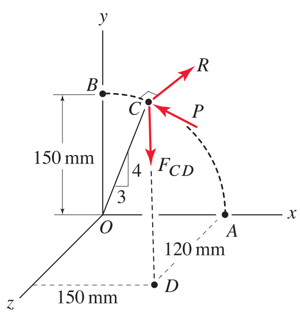
3.102 (**a**) $F_{AE} = -420\,\text{lb}$, $F_{AC} = -120\,\text{lb}$, $F_{AD} = -120\,\text{lb}$; (**b**) $F_{EB} = -120\,\text{lb}$.



3.104 $F_{AB} = F_{AC} = 780\,\text{lb}$, $R = 800\,\text{lb}$.

3.106 $W = 400\,\text{N}$, $R_1 = 291\,\text{N}$, $R_2 = 72.8\,\text{N}$, $\vec{R}_1 = (28.2\,\hat{\imath} + 198\,\hat{\jmath} + 212\,\hat{k})\,\text{N}$, $\vec{R}_2 = (-68.3\,\hat{\imath} + 22.3\,\hat{\jmath} - 11.8\,\hat{k})\,\text{N}$.

3.108 $P = 107\,\text{N}$, $\vec{R} = (32.0\,\hat{\imath} + 42.6\,\hat{\jmath} - 107\,\hat{k})\text{N}$.



3.110 $W = 68.52\,\text{lb}$.

3.112 151.5 N.

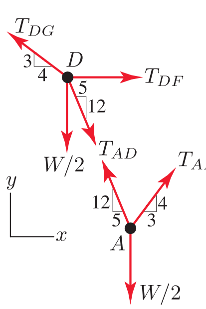
3.114 $F_{ED} = 280\,\text{lb}$, $F_{EF} = 360\,\text{lb}$, $F_{FB} = 210\,\text{lb}$, $F_{EA} = 380\,\text{lb}$, $F_{FC} = 210\,\text{lb}$, 60 lb must be added to traffic light E.

3.116 (**a**) $T_{AB} = -96.75\,\text{lb}$, $T_{AC} = 114.3\,\text{lb}$; (**b**) $k_{AB} = 297.4\,\text{lb/in.}$, $k_{AC} = 461.4\,\text{lb/in.}$

3.118 Essay-type answer.

3.120 For scenario (a): $T_{AB} = 4000\,\text{lb}$, for scenario (b): $T_{AD} = 2611\,\text{lb}$.

3.122 $T_{AE} = 44.6\,\text{lb}$, $T_{AD} = 69.6\,\text{lb}$, $T_{DF} = 192\,\text{lb}$, $T_{DG} = 274\,\text{lb}$, $T_{ABCD} = 100\,\text{lb}$.



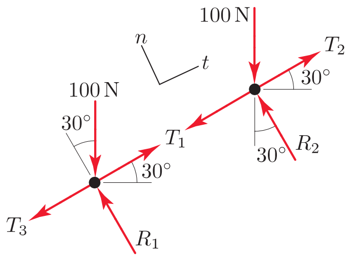
3.124 $T_{AB} = -2625\,\text{lb}$, $T_{BC} = -1250\,\text{lb}$, $T_{BD} = 2125\,\text{lb}$, $T_{CD} = 750\,\text{lb}$, $T_{CE} = 1000\,\text{lb}$.

3.126 $\theta = 19.1°$, $T_{AB} = 153\,\text{N}$.

3.128 $FS = 1.5$.

3.130 $F = 90.1\,\text{N}$.

3.132 $\delta_1 = 10.0\,\text{mm}$, $\delta_2 = 10.0\,\text{mm}$.



3.134 $T_{AB} = 9.33\,\text{kN}$, $T_{AC} = 9.33\,\text{kN}$, $T_{AD} = 16.0\,\text{kN}$, $T_{AE} = 8.00\,\text{kN}$.

3.136 $T_{AB} = 8.40\,\text{kN}$, $T_{AC} = 4.40\,\text{kN}$, $T_{AD} = 8.00\,\text{kN}$, $T_{AE} = 8.00\,\text{kN}$.

3.138 $T_{AB} = 275.4\,\text{lb}$, $R_y = 130.9\,\text{lb}$, $R_n = 479.8\,\text{lb}$.

3.140 $P = 30$ lb, $T_{BE} = 70$ lb, reactions for collar B: $R_{Bx} = 60$ lb, $R_{By} = -30$ lb, reactions for collar E: $R_{Ex} = -60$ lb, $R_{Ez} = 40$ lb.

3.142 The bead slides toward B.

3.144 $T_{AC} = 1650\,\text{lb}$, $T_{BC} = 106\,\text{lb}$, $T_{CD} = 2330\,\text{lb}$, $F_{CE} = -1471\,\text{lb}$, $F_{CF} = -1471\,\text{lb}$, $T_{BG} = 600\,\text{lb}$, $P = 106\,\text{lb}$.

3.146 **(a)** $T_{AB} = -5000\,\text{lb}$, $T_{AC} = 7071\,\text{lb}$, $d = 5.063$ in.; **(b)** $P = 3884\,\text{lb}$; **(c)** Essay-type answer.

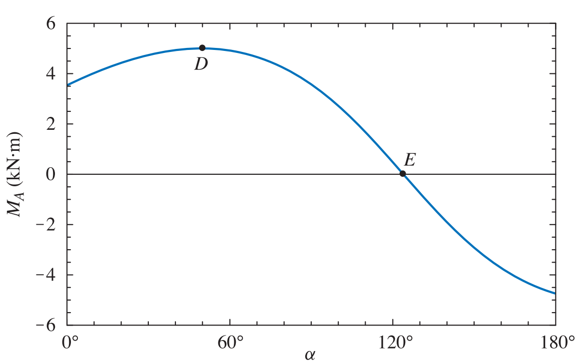
Chapter 4

Note: Throughout Ch. 4, unless otherwise stated, answers for two-dimensional problems are reported using positive values for counterclockwise moments and negative values for clockwise moments. Answers for three-dimensional problems are reported using positive values for moments that act in the positive coordinate directions and negative values for moments that act in the negative coordinate directions.

4.2 **(a)** $d = 6.00$ in., $M_B = -150$ in.·lb; **(b)** $M_B = -150$ in.·lb; **(c)** $M_B = -150$ in.·lb; **(d)** $M_B = -150$ in.·lb; **(e)** $\vec{M}_B = -150\,\hat{k}$ in.·lb.

4.4 **(a)** $d = 14.1$ mm, $M_B = -42.4$ N·mm; **(b)** $M_B = -42.4$ N·mm; **(c)** $M_B = -42.4$ N·mm; **(d)** $M_B = -42.4$ N·mm; **(e)** $\vec{M}_B = -42.4\,\hat{k}$ N·mm.

4.6 $M_A = \frac{2\ \sin\alpha + 3\ \cos\alpha}{\sqrt{14 - 6\ \sin\alpha + 4\ \cos\alpha}}\,5$ kN·m.



4.8 **(a)** $F = 20.1$ lb; **(b)** $F = 56.1$ lb; **(c)** $k = 13.0$ lb/in.

4.10 $F = 640$ lb, $\alpha = 140°$.

4.12 **(a)** $M_A = 30.0$ kN·m; **(b)** $M_A = 35.0$ kN·m; **(c)** $M_A = 38.0$ kN·m.

4.14 **(a)** $Q = 10.0$ kN; **(b)** $W = 5.00$ kN, $\alpha = 53.1°$. **Hint:** In Part (b), the value of W you determine must not produce a moment about point A that exceeds 20 kN·m for any possible value of α.

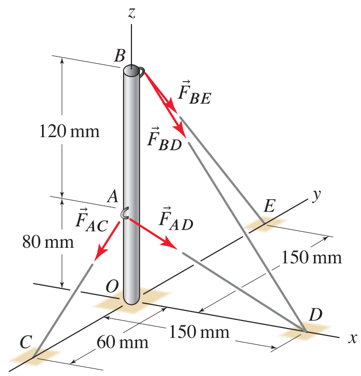
4.16 Open-end wrench: $\vec{M}_O = (194.2\,\hat{\jmath} + 120\,\hat{k})$ in.·lb, ratchet-wrench: $\vec{M}_O = (-121.4\,\hat{\imath} + 194.2\,\hat{\jmath} + 73.65\,\hat{k})$ in.·lb, the open-end wrench is probably more effective.

4.18 $F = -100$ N.

4.20 **(a)** and **(b)** $\vec{M}_A = (184.6\,\hat{\imath} + 3.077\,\hat{\jmath} - 129.2\,\hat{k})$ kN·m.

4.22 (**a**) $\vec{M}_B = (3570\,\hat{\imath} + 286\,\hat{\jmath} - 3000\,\hat{k})$ in.·lb; (**b**) $\vec{M}_O = (8030\,\hat{\imath} + 514\,\hat{\jmath} - 3000\,\hat{k})$ in.·lb.

4.24 (**a**) $\vec{M}_A = (-7200\,\hat{\imath} + 7200\,\hat{\jmath})$ N·mm; (**b**) $\vec{M}_B = (29{,}600\,\hat{\jmath})$ N·mm.



4.26 (**a**) $\vec{M}_B = (-4600\,\hat{\imath} - 2880\,\hat{k})$ ft·lb; (**b**) $\vec{M}_A = (-2300\,\hat{\imath} + 1920\,\hat{\jmath} - 2880\,\hat{k})$ ft·lb; (**c**) $\vec{M}_O = (-3840\,\hat{\imath} + 7680\,\hat{\jmath} - 2880\,\hat{k})$ ft·lb.

4.28 $F = 1.75$ kN.

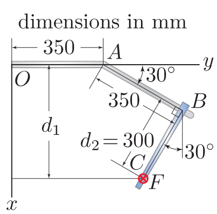
4.30 (**a**) $F = 240$ N, (**b**) $\vec{M}_O = 288\,\hat{\imath}$ N·m; (**c**) Essay-type answer.

4.32 Points A and B lie on a line that is parallel to the line of action of the force.

4.34 (**a**) $M_{AB} = 1900$ N·mm, $\vec{F} = (-3.85\,\hat{\imath} + 9.23\,\hat{k})$ N, $\vec{F} = (3.85\,\hat{\imath} - 9.23\,\hat{k})$ N is also acceptable; (**b**) $M_{AB} = 472$ N·mm; (**c**) $M_{AB} = 0$.

4.36 $F = 92.6$ lb.

4.38 $F = 115$ N. Twisting occurs at both fittings on pipe OA.



4.40 $M_{AB}^{\text{Strength}} = 8$ in.·lb, $M_{BC}^{\text{Strength}} = 4.992$ in.·lb.

4.42 (**a**) $\vec{M}_A = (2.29\,\hat{\imath} + 10.3\,\hat{\jmath} + 2.29\,\hat{k})$ N·mm, $M_{AB} = -8.00$ N·mm; (**b**) $\vec{M}_B = (12.0\,\hat{\imath} - 6.00\,\hat{k})$ N·mm, $M_{AB} = -8.00$ N·mm; (**c**) Essay-type answer.

4.44 $M_a = -19{,}850$ N·cm.

4.46 $M_{AB} = -817.5$ N·cm.

4.48 $M_{BCD} = -263.8$ in.·lb. **NOTE:** The first printing of this book has an error in the figure for this problem. The y coordinate of point D should be 25 in., hence its location is $D(10, 25, 28)$ in. This error is corrected in the second and subsequent printings of the book.

4.50 $M_{OB} = 12.5$ N·m.

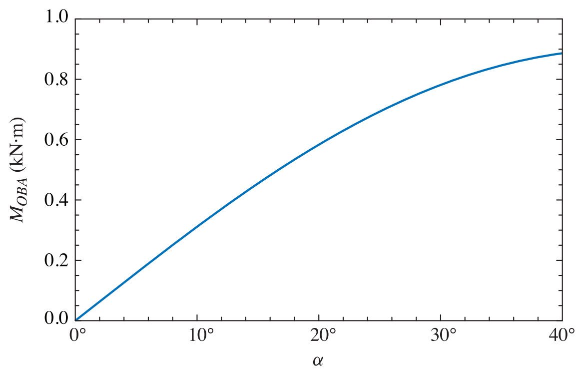
4.52 (**a**) $\vec{M}_A = (9830\,\hat{\imath} + 1940\,\hat{\jmath} + 7770\,\hat{k})$ N·mm, $M_a = 11300$ N·mm; (**b**) $\vec{M}_O = 14000\,\hat{\imath}$ N·mm, $M_a = 11300$ N·mm.

4.54 $\vec{F} = (13.4\,\hat{\jmath} + 6.71\,\hat{k})$ lb, $M_{GH} = 537$ in.·lb.

4.56 $\vec{Q} = (6\,\hat{\imath} + 6\,\hat{\jmath} + 3\,\hat{k})$ lb, $M_{BC} = -290$ in.·lb.

4.58 $M_a = -17{,}400$ ft·lb, $\alpha = 90°$.

4.60 $M_{OBA} = \cos\alpha \sin\alpha$ (1.8 kN·m).



4.62 $P_{\text{max}} = 1546$ N.

4.64 $M = 144$ in.·lb.

4.66 **(a)** $Q = 120$ N; **(b)** The answer does not change.

4.68 $F_B = 80$ lb, $\beta = 70°$, $M = 3363$ in.·lb.

4.70 **(a)** $M = 96.6$ N·mm; **(b)** $M = 96.6$ N·mm.

4.72 **(a)** $F_A = 200$ N, $\alpha = 22.62°$, $M = 2400$ N·cm; **(b)** $F_1 = F_2 = -123.8$ N; **(c)** $Q_1 = Q_2 = 133.3$ N; **(d)** $M_A = 2400$ N·cm.

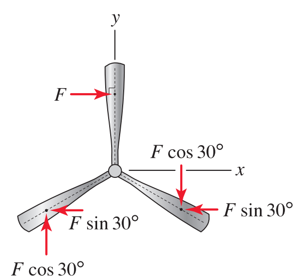
4.74 $F_B = 18.93$ lb.

4.76 $\vec{M} = (200\,\hat{\imath} - 600\,\hat{k})$ N·m.

4.78 $d = 1.92$ m.

4.80 **(a)** $\vec{M} = (-800\,\hat{\imath} - 200\,\hat{\jmath})$ N·m; **(b)** Essay-type answer.

4.82 The forces F are resolved into horizontal and vertical components as shown. The two vertical forces $F\cos 30°$ constitute one couple. The two horizontal forces $F \sin 30°$ and the horizontal force F constitute another couple.

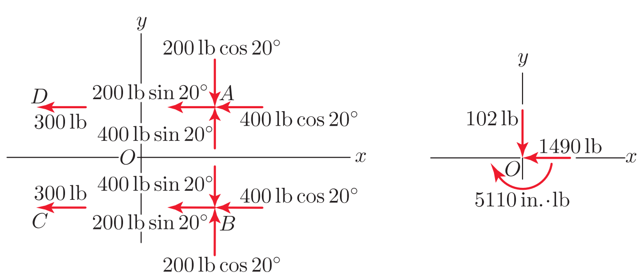


4.84 Force systems (a) and (c) are equivalent.

4.86 Force systems (a) and (d) are equivalent, and force systems (b) and (c) are equivalent.

4.88 For force system (b), $F = 2$ kip and $P = 4$ kip; for force system (c), there are no values for F and P such that force systems (a) and (c) will be equivalent; for force system (d), $F = 5$ kip and $P = -1$ kip.

4.90 $F_{Rx} = -1490$ lb, $F_{Ry} = -102$ lb, M_R−5110 in.·lb. The original force system and the force system at point O are shown below.



4.92 $\vec{F}_R = (144.5\,\hat{\imath} + 2091\,\hat{\jmath} + 17{,}000\,\hat{k})$ lb, $\vec{M}_{RO} = (-31{,}650\,\hat{\imath} + 2402\,\hat{\jmath} - 795.2\,\hat{k})$ ft·lb.

4.94 $F_{Rx} = -0.500$ kN, $F_{Ry} = -3.87$ kN, 2.58 m to the right of the bearing at C.

4.96 $F_{Rx} = -49.24$ lb, $F_{Ry} = -41.32$ lb, $x = 9.342$ in.

4.98 **(a)** $\vec{F}_R = (-1800\,\hat{k})$ N, $\vec{M}_{RO} = (6.94\,\hat{\imath} - 12.0\,\hat{\jmath})$ N·m; **(b)** $\vec{F}_R = (-1800\,\hat{k})$ N, $(x, y) = (-3.86\,\text{mm}, -6.67\,\text{mm})$.

4.100 **(a)** $\vec{F}_R = (-5.00\,\hat{\imath} + 50.0\,\hat{\jmath} - 10.0\,\hat{k})$ nN, $\vec{M}_{RB} = (120\,\hat{\imath} - 60.0\,\hat{k})$ nN·μm; **(b)** $\vec{F}_R = (-5.00\,\hat{\imath} + 50.0\,\hat{\jmath} - 10.0\,\hat{k})$ nN, $\vec{M}_{RO} = (220\,\hat{\imath} + 800\,\hat{\jmath} + 3890\,\hat{k})$ nN·μm.

4.102 **(a)** $\vec{F}_R = (10.0\,\hat{\jmath})$ kN, $\vec{M}_{RA} = (25.0\,\hat{\imath} + 4.00\,\hat{\jmath} + 20.0\,\hat{k})$ kN·m; **(b)** $F_{Rx} = 0$, $F_{Ry} = 10.0$ kN, $F_{Rz} = 0$, $M_{RAx} = 25.0$ kN·m, $M_{RAy} = 4.00$ kN·m, $M_{RAz} = 20.0$ kN·m.

4.104 $\vec{F}_R = -2F\,\hat{k}$, $\vec{M}_R = 3Pr\,\hat{k}$, $(x, y) = (0, r)$.

4.106 $\vec{F}_R = (2.00\,\hat{\imath} + 3.00\,\hat{\jmath} - 4.00\,\hat{k})$ N, $\vec{M}_{RA} = (9.00\,\hat{\imath} + 8.00\,\hat{\jmath} - 4.00\,\hat{k})$ N·m.

4.108 $\vec{F}_R = F(-\hat{\jmath} + \hat{k})$, $\vec{M}_R = Fa\frac{1}{2}(-\hat{\jmath} + \hat{k})$, $(x, y) = (\frac{1}{2}a, b)$.

4.110 $\vec{M}_R = (150\,\hat{\imath} + 104\,\hat{\jmath} - 200\,\hat{k})$ N·m.

4.112 $F = 444.4$ N.

4.114 **(a)** $M_a = 256$ N·m; **(b)** $\hat{u} = -0.530\,\hat{\imath} + 0.662\,\hat{\jmath} + 0.530\,\hat{k}$.

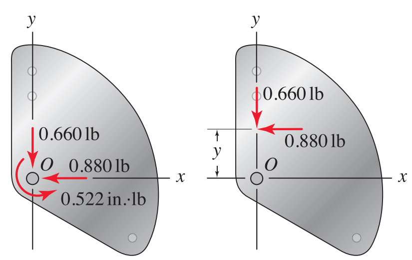
4.116 $F = 300$ lb.

4.118 $M_a = -311.0$ in.·lb.

4.120 $M = -9638$ N·mm.

4.122 $P = -10$ lb, $Q = -5$ lb, $R = 0$, $S = -20$ lb, $M_D = -10$ in.·lb.

4.124 **(a)** $F_{Rx} = -0.880$ lb, $F_{Ry} = -0.660$ lb, $M_O = 0.552$ in.·lb; **(b)** $F_{Rx} = -0.880$ lb, $F_{Ry} = -0.660$ lb, $y = 0.627$ in.



force system 2 force system 3

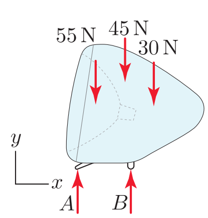
4.126 **(a)** $F_{Rx} = 0$, $F_{Ry} = -1800$ lb, $F_{Rz} = 0$, $M_{Ax} = 8700$ ft·lb, $M_{Ay} = 0$, $M_{Az} = 26{,}700$ ft·lb; **(b)** $F_{Rx} = 0$, $F_{Ry} = -1800$ lb, $F_{Rz} = 0$, $x = 12.2$ ft, $z = 7.83$ ft.

4.128 $\vec{F}_R = (-30.0\,\hat{\imath} - 120\,\hat{\jmath} - 22.5\,\hat{k})$ lb, $\vec{M}_{RO} = (-990\,\hat{\imath} + 60.0\,\hat{\jmath} + 1180\,\hat{k})$ in.·lb.

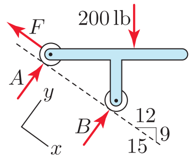
Chapter 5

Note: Throughout Ch. 5, unless otherwise stated, the following conventions apply. Answers for two-dimensional problems are referred to an xy coordinate system where x is horizontal with positive to the right, and y is vertical with positive upward. Answers are reported so that positive forces act in positive coordinate directions, and positive moments are counterclockwise. For three-dimensional problems, moments are reported using positive values for moments that act in the positive coordinate directions.

5.2 $A = 23.5$ N, $B = 107$ N.



5.4 $F = 120\,\text{lb}$, $B = 213\,\text{lb}$, $A = -53.5\,\text{lb}$, essay-type answer.



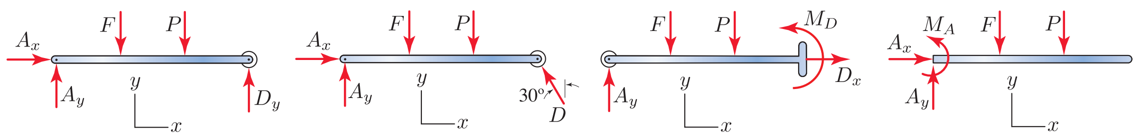
5.6 $T_{DE} = -258.1$ lb, $N = 377.6$ lb, $T_{BC} = 77.30$ lb.

5.8 $B = 42.9\,\text{N}$ (force supported by *one* link), $A_x = 68.6\,\text{N}$, $A_y = -31.4\,\text{N}$.

5.10 If $0 \le \beta < 51.32°$, the spool will roll to the left, and if $51.32° < \beta \le 180°$, the spool will roll to the right.

5.12 $d = 3.10\,\text{ft}$.

5.14 **(a)** $A_y = \frac{2}{3}F + \frac{1}{3}P$, $A_x = 0$, $D_y = \frac{1}{3}F + \frac{2}{3}P$; **(b)** $A_x = 0.192F + 0.385P$, $A_y = \frac{2}{3}F + \frac{1}{3}P$, $D = 0.385F + 0.770P$; **(c)** $A_y = F + P$, $D_x = 0$, $M_D = \frac{1}{3}L(F + 2P)$; **(d)** $A_x = 0$, $A_y = F + P$, $M_A = \frac{1}{3}L(F + 2P)$.



5.16 $A_y = 1.88\,\text{kN}$, $E_y = 2.12\,\text{kN}$, $E_x = -2.00\,\text{kN}$.

5.18 $A_x = 0$, $A_y = 3.00\,\text{kip}$, $P_y = 1.00\,\text{kip}$.

5.20 $C_y = 11{,}300\,\text{lb}$, $D_y = 6170\,\text{lb}$.

5.22 $A_x = 0$, $B_y = P$, $M_A = Pa$.

5.24 $C_y = 1516$ lb, $A_x = 845.2$ lb, $A_y = 582.5$ lb.

5.26 **(a)** $T = 75$ lb, $B_x = 112.4$ lb, $B_y = 49.41$ lb; **(b)** $F_{CD} = 134.2$ lb, $B_x = 12.44$ lb, $B_y = 139.4$ lb.

5.28 $C_n = 11{,}940$ N, $B_x = 10{,}880$ N, $B_y = 6856$ N.

5.30 **(a)** $P = 50$ N; **(b)** Rollers B and C make contact, $A_y = 0$, $B_y = -10$ N, $C_y = 100$ N, $D_y = 0$.

5.32 Rollers B and C make contact, $A_y = 0$, $B_y = -40.8\,\text{lb}$, $C_y = 231\,\text{lb}$, $D_y = 0$.

5.34 Rollers A and C make contact, $A_y = 193\,\text{lb}$, $B_y = 0$, $C_y = 198\,\text{lb}$, $D_y = 0$.

5.36 **(a)** $A = 498\,\text{lb}$; **(b)** Essay-type answer.

5.38 **(a)** $\alpha > 75.5°$; **(b)** $\alpha > 90.0°$

5.40 Essay-type answer.

5.42 $F_x = 9.08\,\text{lb}$, $F_y = -6.91\,\text{lb}$, $E_y = 19.1\,\text{lb}$.

5.44 $T_t = 759.7$ N, $B_x = -777.3$ N, $B_y = 389.1$ N.

5.46 $G = 4.66\,\text{N}$, $N = 17.4\,\text{N}$, $\theta = 17.0°$.

5.48 $A_x = 0$, $A_y = 200\,\text{lb}$, $T = 600\,\text{lb}$.

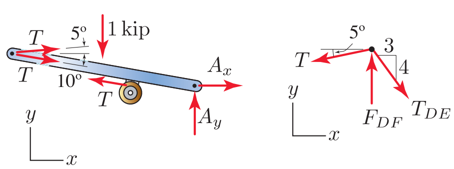
5.50 $A_x = 21.92$ lb, $A_y = -54.22$ lb, $T = 28.61$ lb.

5.52 $F_{BE} = -4.472\,\text{kN}$, $C_x = 2\,\text{kN}$, $C_y = -1\,\text{kN}$. **NOTE:** The first printing of this book has an error in the figure for this problem; the location of point E was not given. Point E is located 0.4 m from the vertical line passing through point C. This error is corrected in the second and subsequent printings of the book.

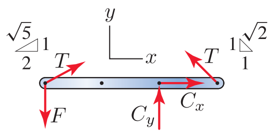
5.54 **(a)** $A_x = 2.59\,\text{kN}$, $A_y = -35.2\,\text{kN}$, $B_y = 54.8\,\text{kN}$; **(b)** $A_x = 7.59\,\text{kN}$, $A_y = -41.2\,\text{kN}$, $B_y = 59.5\,\text{kN}$.

5.56 $F_{BE} = -143.5$ lb, $A_x = -64.62$ lb, $A_y = -89.42$ lb.

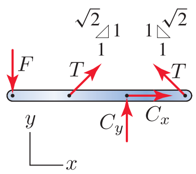
5.58 $T = 1.479\,\text{kip}$ (tension in cable BCD), $A_x = -1.474\,\text{kip}$, $A_y = 0.8711\,\text{kip}$, $T_{DE} = 2.456\,\text{kip}$, $F_{DF} = 2.094\,\text{kip}$.



5.60 (**a**) Complete fixity, statically determinate; (**b**) $T = 10.68F$; *Additional results:* $C_x = -2.000F$, $C_y = -11.32F$.



5.62 (**a**) Partial fixity, statically indeterminate; (**b**) The cable tension cannot be determined; *Additional result:* The equations of static equilibrium require $F = 0$. If $F \neq 0$, then the equations of static equilibrium cannot be satisfied, and dynamic motion occurs.



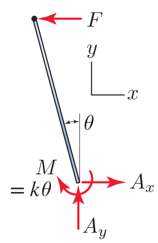
5.64 $F = 13.6$ lb.

5.66 $Q = 191.5$ N, $C_x = -63.40$ N, $C_y = 170.6$ N.

5.68 $F_s = 200$ lb, $P = 81.84$ lb, $A_x = 127.4$ lb, $A_y = -77.75$ lb.

5.70 The pretwist of the torsional spring is 0.7003 turns, $P = 11$ lb.

5.72 (**a**) $\theta = 4.58°$; (**b**) $\theta = 36.7°$; (**c**) Essay-type answer.



5.74 Essay-type answer

5.76 $A_x = 0$, $A_y = F\left[1 - \dfrac{kL^2}{2(k_t + kL^2)}\right]$, $C_y = \dfrac{FkL^2}{2(k_t + kL^2)}$, $M_A = \dfrac{FL}{2}\left[1 - \dfrac{kL^2}{k_t + kL^2}\right]$.

5.78 For structure (a), full fixity and statically determinate; for structure (b), full fixity and statically indeterminate; for structure (c), full fixity and statically determinate; for structure (d), partial fixity and statically determinate; for structure (e), full fixity and statically determinate; for structure (f), partial fixity and statically indeterminate.

5.80 $D = 0.314$ N, $L = 1.34$ N.

5.82 $\delta = 2.40$ mm, $\theta = 1.49°$.

5.84 (**a**) $T_{EA} = 1.33$ kip, $B_x = 0$, $B_y = 3.33$ kip; (**b**) $T_{EA} = 12.3$ kip, $B_x = 0$, $B_y = 20.3$ kip; (**c**) $T_{EA} = 15.9$ kip, $B_x = 0$, $B_y = 25.7$ kip.

5.86 ABC is a 3-force member and BD is a 2-force member.

5.88 $ABDE$ is a multiforce member and BC is a 2-force member.

5.90 3-force member.

5.92 3-force member.

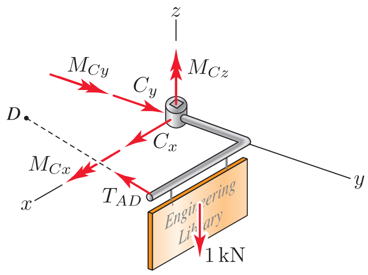
5.94 $ABCD$ is a multiforce member and DE is a 2-force member.

5.96 Multiforce member.

5.98 3-force member.

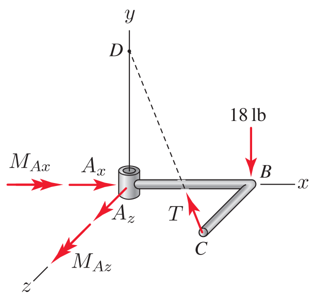
5.100 $F_{AB} = 318$ kN to begin opening the dump when $\theta = 0°$; $F_{AB} = 0$ when the center of gravity G of the dump and its contents is immediately above point O.

5.102 $C_x = -0.333\,\text{kN}$, $C_y = 0.667\,\text{kN}$, $T_{AD} = 1.25\,\text{kN}$, $M_{Cx} = 0$, $M_{Cy} = 2.00\,\text{kN·m}$, $M_{Cz} = 3.33\,\text{kN·m}$.



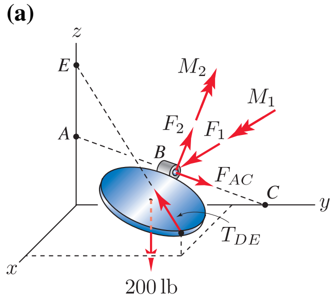
5.104 $A_x = 0$, $A_y = 0$, $A_z = 10$ lb, $M_{Ax} = 120$ in.·lb, $M_{Az} = 0$, $F_z = 20$ lb.

5.106 **(a)** Partial fixity and statically determinate; **(b)** $T = 27\,\text{lb}$, $A_x = 18.0\,\text{lb}$, $A_z = 9.00\,\text{lb}$, $M_{Ax} = 54.0\,\text{in.·lb}$, $M_{Az} = 0$.

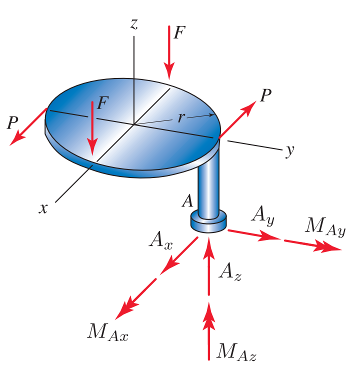


5.108 $T_{AD} = 50.75\,\text{kN}$.

5.110 **(b)** 2, 0, 4, 1, 3;
(a)



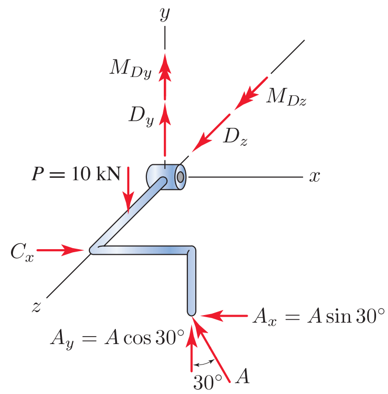
5.112 $A_x = 0$, $A_y = 0$, $A_z = 2F$, $M_{Ax} = -2Fr$, $M_{Ay} = 0$, $M_{Az} = -2Pr$.



5.114 $B_x = -0.01$ lb, $B_y = -0.001429$ lb, $B_z = 0.1150$ lb, $M_{Bx} = -0.08571$ in.·lb, $E_y = 0.001429$ lb, $E_z = 0.0850$ lb.

5.116 $F = 3.21\,\text{kN}$, $C_x = -3.00\,\text{kN}$, $C_y = -0.429\,\text{kN}$, $C_z = 2.07\,\text{kN}$, $M_{Cx} = 0.343\,\text{kN·m}$, $M_{Cz} = -0.600\,\text{kN·m}$.

5.118 $A = 5.77\,\text{kN}$, $C =_x 2.89\,\text{kN}$, $D_y = 5.00\,\text{kN}$, $D_z = 0$, $M_{Dy} = 0$, $M_{Dz} = -9.23\,\text{kN·m}$.



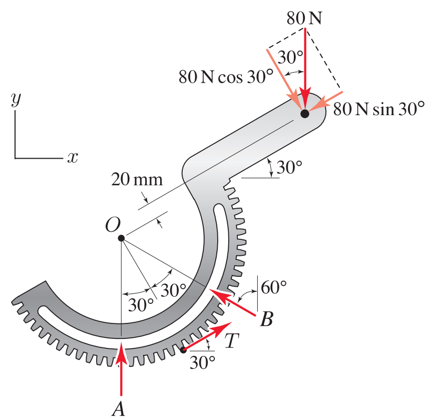
5.120 Statically determinate, $Q = 833.3$ lb, $A_x = 1667$ lb, $A_y = 0$, $A_z = 4313$ lb, $C_x = -2500$ lb, $C_z = -162.5$ lb.

5.122 **(a)** Statically indeterminate; **(b)** $T_{CF} = 2289$ N.

5.124 **(a)** $A_x = 38$ kN, $A_y = 50$ kN, $M_A = -1281$ kN·m; **(b)** $T_{BF} = 153.8$ kN; **(c)** $T_{BF} = 93.76$ kN.

5.126 Essay-type answer; *partial answer:* the propellers rotate counterclockwise.

5.128 $T = 163\,\text{N}$, $A = -83.2\,\text{N}$, $B = 163\,\text{N}$.



5.130 $A_x = 7.00\,\text{N}$, $A_y = 26.1\,\text{N}$, $M_A = -276\,\text{N·cm}$.

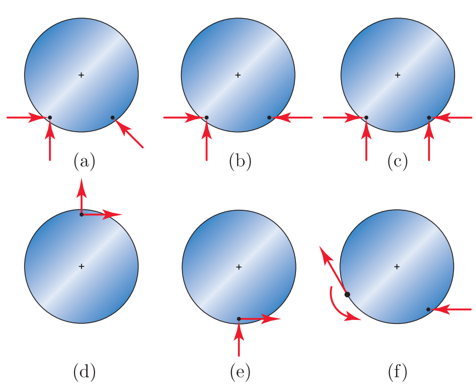
5.132 $T = 16.74$ lb, $T_{JK} = 14$ lb.

5.134 $k_t = 1.034\,\text{in.·lb/rad}$, $\theta_0 = 3.142$ rad.

5.136 **(a)** $F = 3.29\,\text{N}$; **(b)** $F = 11.5\,\text{N}$; **(c)** $F = 20.1\,\text{N}$.

5.138 **(a)** Statically indeterminate; **(b)** $F_{AE} = 833.3$ lb (compression), $T_{CG} = 1167$ lb (tension), $B_x = -1732$ lb, $B_y = 666.7$ lb.

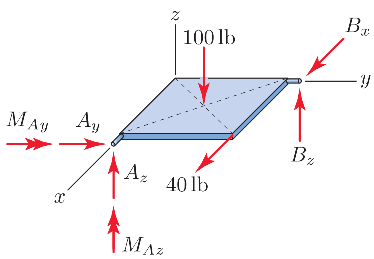
5.140 For structure (a), full fixity and statically determinate; for structure (b), partial fixity and statically indeterminate; for structure (c), full fixity and statically indeterminate; for structure (d), partial fixity and statically determinate; for structure (e), partial fixity and statically determinate; for structure (f), full fixity and statically indeterminate.



5.142 (**a**) Essay-type answer; (**b**) $T_1 = 15.7$ lb, $T_2 = 21.5$ lb, $O_x = 13.3$ lb, $O_y = 11.5$ lb, $O_z = -19.4$ lb.

5.144 $P = 444.4$ lb, $A_x = 307.2$ lb, $A_y = 204.5$ lb, $A_z = -355.6$ lb, $B_x = 209.5$ lb, $B_y = -54.50$ lb.

5.146 (**a**) Full fixity and statically determinate; (**b**) $A_y = 0$, $A_z = 60.0$ lb, $B_x = -40.0$ lb, $B_z = 40.0$ lb, $M_{Ay} = 200$ in.·lb, $M_{Az} = -80.0$ in.·lb.



5.148 **d** – Object 1 *could never be* in equilibrium; Object 2 *could be* in equilibrium.

5.150 **c** – Object 1 *could be* in equilibrium; Object 2 *could never be* in equilibrium.

Chapter 6

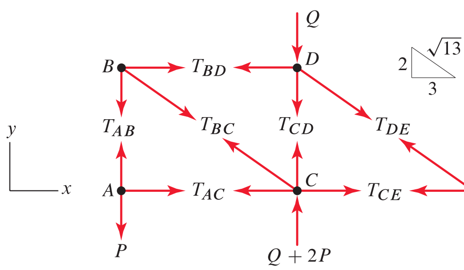
6.2 $T_{AB} = -500$ lb, $T_{AC} = 0$, $T_{BC} = 625$ lb, $T_{BD} = -375$ lb, $T_{CD} = 625$ lb, $T_{CE} = 0$, $T_{DE} = -500$ lb.

6.4 $P = 3200$ lb.

6.6 $P = 8000$ lb.

6.8 $T_{CE} = 3.75$ kN, $T_{DF} = -3.66$ kN.

6.10 $T_{AB} = 4.00$ kN, $T_{AC} = 0$, $T_{BC} = -7.21$ kN, $T_{BD} = 6.00$ kN, $T_{CD} = -5.00$ kN, $T_{CE} = -6.00$ kN, $T_{DE} = 7.21$ kN.



6.12 $P = 10.0$ kN.

6.14 $P = 6.66$ kN.

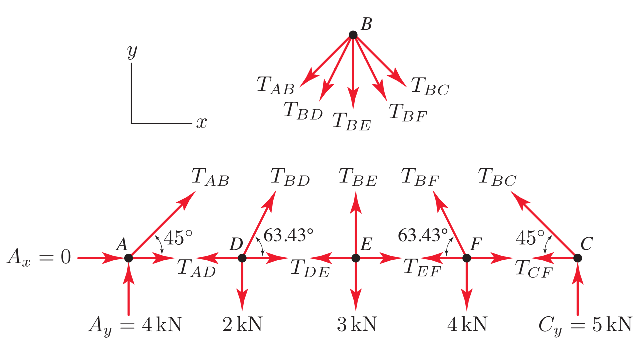
6.16 1.92.

6.18 1.77.

6.20 $T_{AB} = -F$, $T_{AE} = \sqrt{2}F$, $T_{CD} = 0$, $T_{CE} = 0$, $T_{DB} = -\sqrt{2}F$, $T_{DE} = F$, $T_{EB} = -F$.

6.22 $T_{AB} = 3333$ lb, $T_{AC} = -2667$ lb, $T_{BC} = -4667$ lb, $T_{BE} = 3771$ lb, $T_{CE} = -2667$ lb.

6.24 $T_{AB} = -5.66$ kN, $T_{AD} = 4.00$ kN, $T_{BC} = -7.07$ kN, $T_{BD} = 2.24$ kN, $T_{BE} = 3.00$ kN, $T_{BF} = 4.47$ kN, $T_{CF} = 5.00$ kN, $T_{DE} = 3.00$ kN, $T_{EF} = 3.00$ kN.



6.26 BD, CD, GH.

6.28 AB, CD, EF.

6.30 BD, CD, EF.

6.32 **(a)** FG, DG; **(b)** $T_{FG} = 0$, $T_{DG} = 0$, $T_{AC} = -12.0\,\text{kN}$, $T_{AB} = 10.4\,\text{kN}$, $T_{CB} = 4.00\,\text{kN}$, $T_{BD} = 10.4\,\text{kN}$, $T_{GH} = -8.00\,\text{kN}$, $T_{FH} = 6.93\,\text{kN}$, $T_{EG} = -8.00\,\text{kN}$, $T_{CE} = -8.00\,\text{kN}$, $T_{DE} = 8.00\,\text{kN}$, $T_{CD} = -4.00\,\text{kN}$, $T_{DF} = 6.93\,\text{kN}$.

6.34 $T_{AB} = -3\,\text{kip}$, $T_{AC} = -6.25\,\text{kip}$, $T_{AD} = 3.75\,\text{kip}$, $T_{BD} = -4\,\text{kip}$, $T_{CD} = -5\,\text{kip}$, $T_{CE} = -15\,\text{kip}$, $T_{CF} = 6.25\,\text{kip}$, $T_{DF} = -6.75\,\text{kip}$.

6.36 **(a)** BG, DI, EJ, DE, CD, CH; **(b)** $T_{BG} = 0$, $T_{CH} = 0$, $T_{AB} = -3.00\,\text{kip}$, $T_{AF} = -5.20\,\text{kip}$, $T_{BC} = -3.00\,\text{kip}$, $T_{CF} = -7.21\,\text{kip}$, $T_{FG} = 6.00\,\text{kip}$, $T_{CG} = 5.00\,\text{kip}$, $T_{GH} = 3.00\,\text{kip}$; **(c)** $T_{DI} = 0$, $T_{EJ} = 0$, $T_{DE} = 0$, $T_{CD} = 0$, $T_{CJ} = -14.4\,\text{kip}$, $T_{IJ} = 9.00\,\text{kip}$, $T_{CI} = 10.0\,\text{kip}$, $T_{HI} = 3.00\,\text{kip}$.

6.38 $T_{AB} = 0$, $T_{AD} = -20\,\text{lb}$, $T_{BC} = 0$, $T_{BD} = -29.15\,\text{lb}$, $T_{BF} = -29.15\,\text{lb}$, $T_{CF} = -30\,\text{lb}$, $T_{DE} = 15\,\text{lb}$, $T_{DG} = -65\,\text{lb}$, $T_{EF} = 15\,\text{lb}$, $T_{EG} = -29.15\,\text{lb}$, $T_{EH} = -29.15\,\text{lb}$, $T_{FH} = -85\,\text{lb}$, $T_{GH} = 15\,\text{lb}$.

6.40 $T_{BD} = -0.577P$, $T_{CD} = 0.577P$, $T_{CE} = 0.289P$.

6.42 $T_{CE} = 5.667\,\text{kN}$, $T_{DE} = -4.807\,\text{kN}$, $T_{DF} = -9.000\,\text{kN}$.

6.44 $F_{CD} = -485.3\,\text{lb}$, $F_{CI} = -159.1\,\text{lb}$, $F_{IJ} = 970.6\,\text{lb}$.

6.46 **(a)** DE, HI, JK, LM, NO; **(b)** eliminate DE, HI, LM, essay-type answer; **(c)** $T_{GH} = \frac{5}{8}Q$.

6.48 **(a)** HI, JK, LM; **(b)** eliminate JK, essay-type answer; **(c)** $T_{FG} = 2.00\,\text{kN}$.

6.50 **(a)** Statically determinate; **(b)** $T_{CD} = -8.00\,\text{kip}$, $T_{DE} = 0$, $T_{AD} = 10.4\,\text{kip}$, $T_{BD} = -10.4\,\text{kip}$.

6.52 $T_{CE} = -18{,}667\,\text{lb}$, $T_{DE} = 5833\,\text{lb}$, $T_{EF} = -3000\,\text{lb}$, $T_{EG} = -14{,}000\,\text{lb}$.

6.54 $T_{GI} = -10{,}000\,\text{lb}$, $T_{HI} = 4167\,\text{lb}$, $T_{IJ} = 0$, $T_{IK} = -4000\,\text{lb}$, $T_{IL} = -3333\,\text{lb}$.

6.56 **(a)** $T_{JT} = 40.2\,\text{kN}$; **(b)** $T_{HJ} = 30.0\,\text{kN}$, $T_{IJ} = 14.1\,\text{kN}$, $T_{JK} = 0$, $T_{JM} = 0.563\,\text{kN}$, $T_{JL} = 0.796\,\text{kN}$.

6.58 **(a)** Statically indeterminate; **(b)** mechanism; **(c)** statically indeterminate; **(d)** statically determinate.

6.60 $T_{HJ} = -12\,\text{kip}$, $T_{HK} = 0$, $T_{IK} = 0$, $T_{IL} = 12\,\text{kip}$.

6.62 **(a)** For truss (a): $T_{AB} = -1.41W$, $T_{BD} = -W$, $T_{DF} = -1.41W$, $T_{AC} = W$, $T_{CE} = W$, $T_{EF} = W$, $T_{BC} = W$, $T_{CD} = 0$, $T_{DE} = W$; for truss (b): $T_{AB} = -1.12W$, $T_{BD} = -0.500W$, $T_{DF} = -1.12W$, $T_{AC} = 0.500W$, $T_{CE} = 0.500W$, $T_{EF} = 0.500W$, $T_{BC} = W$, $T_{CD} = 0$, $T_{DE} = W$; **(b)** Essay-type answer; **(c)** Essay-type answer; **(d)** Essay-type answer.

6.64 $P_{\text{crit}} = k_t/L$.

6.66 **(a)** Partial fixity; **(b)** statically determinate; **(c)** $T_{AB} = 0$, $T_{AC} = 0$, $T_{AD} = 4.00\,\text{kN}$, $T_{BC} = 0.417\,\text{kN}$, $T_{BD} = -2.13\,\text{kN}$, $T_{BE} = -0.838\,\text{kN}$, $T_{CD} = -2.13\,\text{kN}$, $T_{CE} = -0.838\,\text{kN}$, $T_{DE} = 1.33\,\text{kN}$.

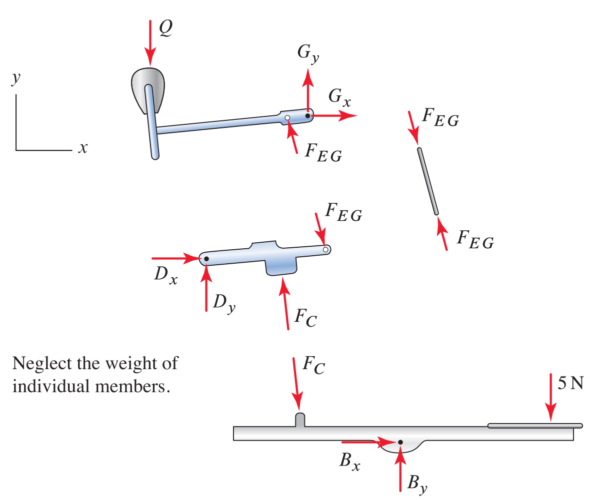
6.68 $T_{AC} = -76.04\,\text{N}$, $T_{BC} = 0$, $T_{CD} = 0$, $T_{CF} = 77.71\,\text{N}$, $T_{CG} = 0$, $T_{CH} = -72.5\,\text{N}$.

6.70 Statically determinate.

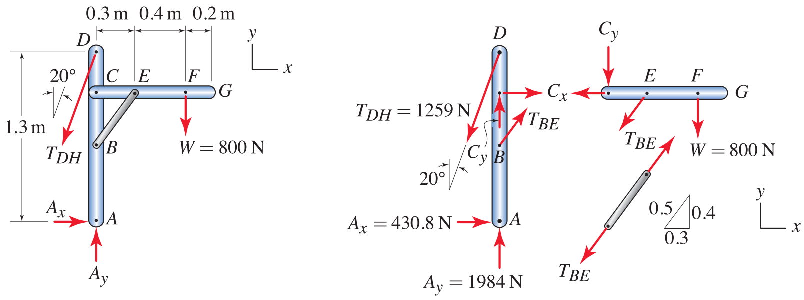
6.72 $T_{MJ} = -10.0\,\text{kN}$.

6.74 $T_{JG} = -15.0\,\text{kN}$.

6.76



6.78 $A_x = 430.8$ N, $A_y = 1984$ N, $T_{DH} = 1259$ N, $T_{BE} = -2333$ N, $C_x = 1400$ lb, $C_y = 1067$ N.



6.80 Essay-type answer.

6.82 Horizontal force applied by the operator is $Q = 20.8$ lb to the right, $T_{AE} = -6.67$ lb; for the following results, absolute values are reported: $B_x = 5.77$ lb, $B_y = 6.67$ lb, $C_x = 26.6$ lb, $C_y = 6.67$ lb.

6.84 Horizontal force applied by the operator is $Q = 47.7$ N to the right, $F_{BE} = 64.0$ N; for the following results, absolute values are reported: $A_x = 55.7$ N, $A_y = 10.7$ N, $C_x = 103$ N, $C_y = 10.7$ N.

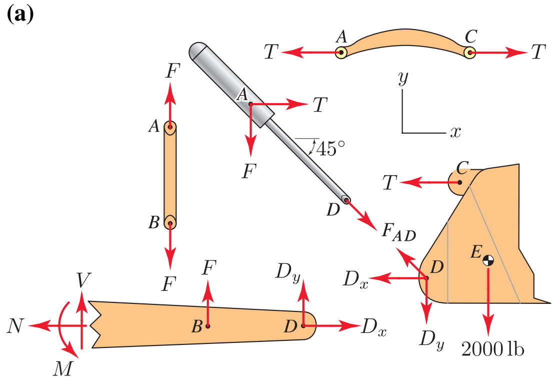
6.86 350 N when $h = 0.9$ m.

6.88 $D_y = 440.7$ lb, $T_{BE} = -1740$ lb.

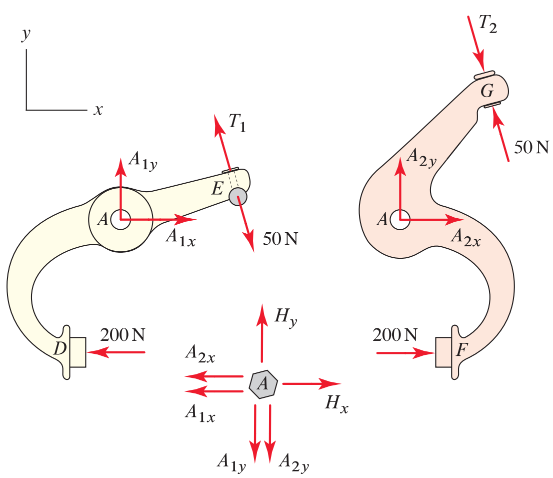
6.90 $D_y = 640.5$ lb, $T_{BE} = 1131$ lb.

6.92 $T_{BG} = 200$ lb, $T_{CG} = -240$ lb, $T_{DG} = 200$ lb.

6.94 **(b)** $F_{AD} = -3390$ lb;
(a)

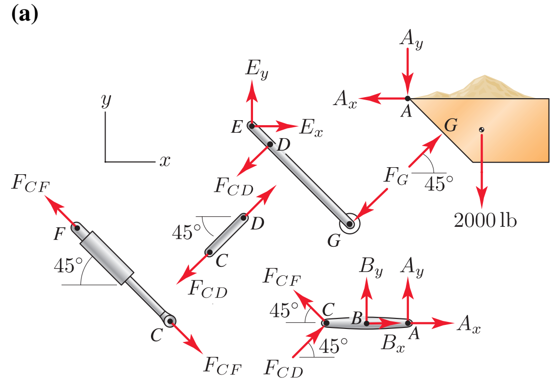


6.96 **(b)** $T_1 = 283$ N, $T_2 = 283$ N; **(c)** $A_{1x} = 260$ N, $A_{1y} = -225$ N, $A_{2x} = -260$ N, $A_{2y} = 225$ N;
(a)



6.98 The chair is safe from collapsing. *Intermediate answer:* $H_y = 21.33$ N (compression). **NOTE:** In the first printing of this book, the hint should refer to the reaction at point H (not point G). This error is corrected in the second and subsequent printings of the book.

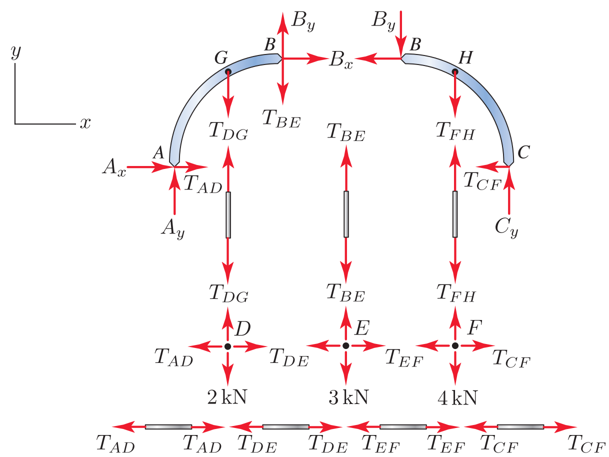
6.100 **(b)** $F_{CF} = 27{,}200\,\text{lb}$;
(a)



6.102 $P = 27.30$ lb.

6.104 $F_{FH} = 22.5\,\text{N}$, $F_{BF} = -70.8\,\text{N}$.

6.106 **(a)** The structure is not a truss, essay-type answer; **(b)** $C_y = 5\,\text{kN}$, $A_x = 0$, $A_y = 4\,\text{kN}$, $T_{DG} = 2.00\,\text{kN}$, $T_{BE} = 3.00\,\text{kN}$, $T_{FH} = 4.00\,\text{kN}$, $T_{AD} = 3.00\,\text{kN}$, $T_{DE} = 3.00\,\text{kN}$, $T_{EF} = 3.00\,\text{kN}$, $T_{CF} = 3.00\,\text{kN}$, $B_x = -3.00\,\text{kN}$, $B_y = 1.00\,\text{kN}$.



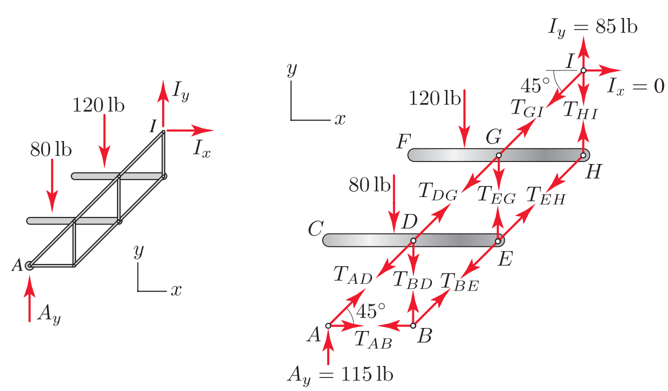
6.108 **(a)** Statically indeterminate; **(b)** HQ and IQ, **(c)** $F_{DG} = \sqrt{2}\,\text{kN}$.

6.110 $T_{BP} = 813\,\text{lb}$, $T_{BO} = 813\,\text{lb}$, $T_{CD} = 100\,\text{lb}$.

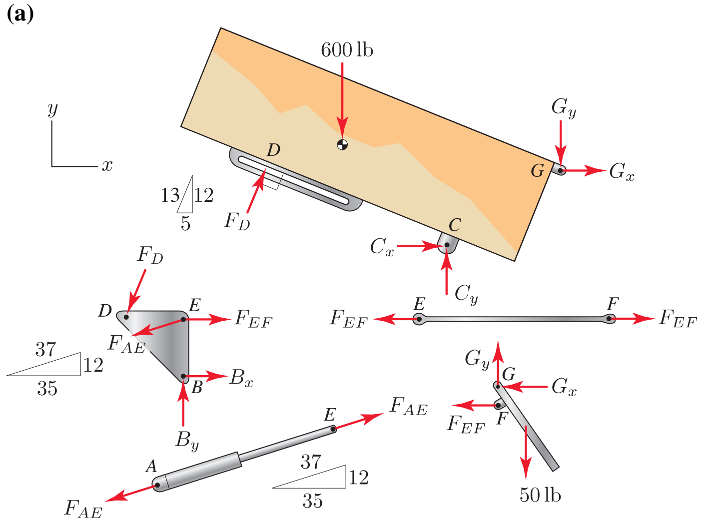
6.112 $T_{BG} = -36.46\,\text{lb}$, $T_{CF} = -1620\,\text{lb}$.

6.114 **(a)** The structure is not a truss; **(b)** Statically indeterminate; **(c)** $E_x = 0$, $E_y = 1.25\,\text{kN}$, $H_y = 1.75\,\text{kN}$, $T_{BF} = 0$, $T_{CH} = -1.094\,\text{kN}$, $T_{DH} = -1.094\,\text{kN}$.

6.116 $T_{AD} = -163\,\text{lb}$, $T_{AB} = 115\,\text{lb}$, $T_{BE} = 163\,\text{lb}$, $T_{BD} = -115\,\text{lb}$, $T_{GI} = 0$, $T_{HI} = 85.0\,\text{lb}$, $T_{EH} = 184\,\text{lb}$, $T_{DG} = -184\,\text{lb}$, $T_{EG} = -35.0\,\text{lb}$.



6.118 **(b)** $F_{AE} = -555.2$ lb;
(a)



Chapter 7

7.2 $(\bar{x}, \bar{y}) = (0, 65.0)$ mm.

7.4 $(\bar{x}, \bar{y}) = (1.18, 1.18)$ in.

7.6 $(\bar{x}, \bar{y}) = (60.8, 30.0)$ mm.

7.8 $(\bar{x}, \bar{y}, \bar{z}) = (2.31, 2.12, 1.42)$ in.

7.10 $(\bar{x}, \bar{y}) = (\frac{9}{20}, \frac{9}{20})$ in.

7.12 $(\bar{x}, \bar{y}) = (\frac{6}{5}, \frac{3}{2})$ m.

7.14 $(\bar{x}, \bar{y}) = (\frac{5}{11}, \frac{83}{110})$ in.

7.16 $(\bar{x}, \bar{y}) = (5.602, 5.167)$ in.

7.18 $(\bar{x}, \bar{y}) = (48.0, 16.0)$ in.

7.20 $y_1 = 2x$, $y_2 = -92 + 4x$, $(\bar{x}, \bar{y}) = (16.44, 13.16)$ cm.

7.22 $(\bar{x}, \bar{y}) = (3.429, 1.429)$ m.

7.24 Answer given in problem statement.

7.26 $c_1 = b/\sqrt{a}$, $c_2 = b/a^3$, $(\bar{x}, \bar{y}) = (\frac{12}{25}a, \frac{3}{7}b)$.

7.28 $L = \int_{3\text{ cm}}^{12\text{ cm}} \frac{1}{3}\sqrt{10}\,dx = 9.487\text{ cm}$, $\bar{x} = \frac{\int_{3\text{ cm}}^{12\text{ cm}} x\frac{1}{3}\sqrt{10}\,dx}{9.487\text{ cm}} = 7.5\text{ cm}$, $\bar{y} = \frac{\int_{3\text{ cm}}^{12\text{ cm}} (2+\frac{x}{3})\frac{1}{3}\sqrt{10}\,dx}{9.487\text{ cm}} = 4.5\text{ cm}$.

7.30 **(a)** $\bar{x} = \frac{\int_0^{1\text{ in.}} x\sqrt{1+9x^4}\,dx}{\int_0^{1\text{ in.}} \sqrt{1+9x^4}\,dx}$, $\bar{y} = \frac{\int_0^{1\text{ in.}} x^3\sqrt{1+9x^4}\,dx}{\int_0^{1\text{ in.}} \sqrt{1+9x^4}\,dx}$; **(b)** $\bar{x} = \frac{\int_0^{1\text{ in.}} y^{1/3}\sqrt{1+\left(\frac{1}{3}y^{-2/3}\right)^2}\,dy}{\int_0^{1\text{ in.}} \sqrt{1+\left(\frac{1}{3}y^{-2/3}\right)^2}\,dy}$, $\bar{y} = \frac{\int_0^{1\text{ in.}} y\sqrt{1+\left(\frac{1}{3}y^{-2/3}\right)^2}\,dy}{\int_0^{1\text{ in.}} \sqrt{1+\left(\frac{1}{3}y^{-2/3}\right)^2}\,dy}$;
(c) $(\bar{x}, \bar{y}) = (0.609, 0.366)$ in.

7.32 **(a)** $\bar{x} = \frac{\int_{-r}^{r} x\sqrt{1+\left(\frac{-x}{\sqrt{r^2-x^2}}\right)^2}\,dx}{\int_{-r}^{r} \sqrt{1+\left(\frac{-x}{\sqrt{r^2-x^2}}\right)^2}\,dx}$, $\bar{y} = \frac{\int_{-r}^{r} \sqrt{r^2-x^2}\sqrt{1+\left(\frac{-x}{\sqrt{r^2-x^2}}\right)^2}\,dx}{\int_{-r}^{r} \sqrt{1+\left(\frac{-x}{\sqrt{r^2-x^2}}\right)^2}\,dx}$; **(b)** $(\bar{x}, \bar{y}) = (0, \frac{2}{\pi}r)$.

7.34 $V = 60.32\text{ in.}^3$, $(\bar{x}, \bar{y}, \bar{z}) = (1.389, 0, 0)$ in.

7.36 $\bar{x} = \frac{11}{28}R$.

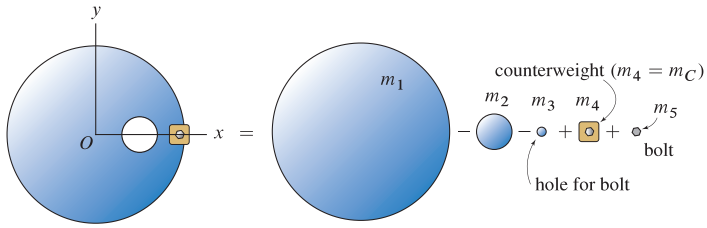
7.38 $d_A = 4938$ m, $d_B = 3.951 \times 10^5$ km.

7.40 The center of gravity is located on the horizontal member of the antenna, at a distance of 133 in. from the left-hand end.

7.42 $(\bar{x}, \bar{y}, \bar{z}) = (2.98, 0, 0)$ in.

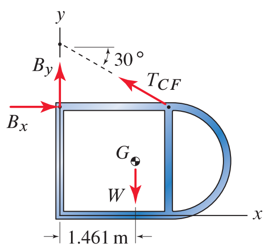
7.44 $\bar{z} = 2.675$ cm.

7.46 $m_c = 680\,\text{g}$.



7.48 $(\bar{x}, \bar{y}, \bar{z}) = (1.07, 0, 0.876)\,\text{in.}$

7.50 The center of mass is located 1.46 m to the right of point A and 1 m above point A, $T = 639\,\text{N}$, $B_x = 553\,\text{N}$, $B_y = 118\,\text{N}$.



7.52 $\bar{x} = 1.447\,\text{in.}$, $m = \frac{106\,\pi\rho_0}{5}\,\text{in.}^3$.

7.54 **(a)** $\bar{x} = \dfrac{\int_0^{r/2} x\frac{\rho_0}{2}\pi(r^2-x^2)dx + \int_{r/2}^{r} x\rho_0\pi(r^2-x^2)dx}{\int_0^{r/2}\frac{\rho_0}{2}\pi(r^2-x^2)dx + \int_{r/2}^{r}\rho_0\pi(r^2-x^2)dx}$, $\bar{y} = 0$, $\bar{z} = 0$; **(b)** $\bar{x} = \frac{25}{56}r$.

7.56 **(a)** $\bar{x} = \dfrac{\int_0^a x\rho_0\pi h^2\left(1-\frac{x^2}{a^2}\right)^2 dx}{\int_0^a \rho_0\pi h^2\left(1-\frac{x^2}{a^2}\right)^2 dx}$, $\bar{y} = 0$, $\bar{z} = 0$; **(b)** $\frac{5}{16}a$.

7.58 **(a)** $\bar{x} = \dfrac{\int_0^L x\gamma_0\pi\left[R^2\left(\frac{x}{L}\right)^{2/3} - \left(\frac{R}{2}\frac{x}{L}\right)^2\right]dx}{\int_0^L \gamma_0\pi\left[R^2\left(\frac{x}{L}\right)^{2/3} - \left(\frac{R}{2}\frac{x}{L}\right)^2\right]dx}$, $\bar{y} = 0$, $\bar{z} = 0$; **(b)** $\bar{x} = \frac{75}{124}L$.

7.60 **(a)** $\bar{y} = \dfrac{\int_0^{1\,\text{cm}} \frac{1}{2}(1+x+x^2)\gamma_0 2\pi x[1+x^2-x]dx}{\int_0^{1\,\text{cm}} \gamma_0 2\pi x[1+x^2-x]dx}$; **(b)** $\bar{x} = \frac{11}{10}\,\text{cm}$.

7.62 $V = 283\,\text{mm}^3$, $A = 226\,\text{mm}^2$.

7.64 $V = 1.78\times10^3\,\text{mm}^3$, $A = 1.98\times10^3\,\text{mm}^2$.

7.66 $V = 8\pi h^3$, $A = \pi h^2(11 + 8\sqrt{2})$.

7.68 $V = 19.8\,\text{in.}^3$, $W = 0.118\,\text{lb}$.

7.70 **(a)** $V = 4.40\times10^5\,\text{mm}^3$; **(b)** $A_{\text{outside}} = 34.6\times10^3\,\text{mm}^2$; **(c)** $A_{\text{inside}} = 12.2\times10^3\,\text{mm}^2$.

7.72 $V = \frac{7\pi}{12}R^3$, $A = \frac{\pi}{4}(11 + \sqrt{5})R^2$.

7.74 **(a)** $w = 2.78\,\text{lb/in.}$ for $0 \le x \le 36\,\text{in.}$; **(b)** $w = 1.85\,\text{lb/in.}$ for $0 \le x \le 18\,\text{in.}$, $w = 3.70\,\text{lb/in.}$ for $18\,\text{in.} \le x \le 36\,\text{in.}$; **(c)** $w = 1.85\,\text{lb/in.} + (0.0514\,\text{lb/in.}^2)x$ for $0 \le x \le 36\,\text{in.}$, **(d)** $w = 1.85\,\text{lb/in.} + (0.103\,\text{lb/in.}^2)x$ for $0 \le x \le 18\,\text{in.}$, $w = 5.56\,\text{lb/in.} - (0.103\,\text{lb/in.}^2)x$ for $18\,\text{in.} \le x \le 36\,\text{in.}$

7.76 $A_x = 0$, $A_y = 33.3\,\text{lb}$, $B_y = 66.7\,\text{lb}$.

7.78 $A_x = 0$, $A_y = 49.1\,\text{kN}$, $M_A = 98.1\,\text{kN}\cdot\text{m}$.

7.80 **(a)** $\bar{x} = 21.0\,\text{in.}$; **(b)** & **(c)** $A_x = 0$, $A_y = 22.2\,\text{lb}$, $B_y = 77.8\,\text{lb}$.

7.82 **(a)** $\bar{x} = 1.67\,\text{m}$; **(b)** & **(c)** $A_x = 0$, $A_y = 49.1\,\text{kN}$, $M_A = 81.8\,\text{kN}\cdot\text{m}$.

7.84 **(a)** $a = \frac{35}{8}\frac{\text{lb}}{\text{in.}}$, $b = -\frac{15}{16}\frac{\text{lb}}{\text{in.}^2}$; **(b)** $w(x = 0) = 4.375\,\text{lb/in.}$, $w(x = 4\,\text{in.}) = 0.625\,\text{lb/in.}$; **(c)** Essay-type answer; **(d)** $A = 17.96\,\text{lb}$, $B = 17.04\,\text{lb}$.

7.86 **(a)** $a = 800\,\text{N/m}$, $b = 0$, $c = -8.00\,\text{N/m}^3$; **(b)** $d = 800\,\text{N/m}$, $f = \frac{\pi}{20\,\text{m}}$.

7.88 $A_x = 0$, $A_y = -4.00\,\text{kN}$, $B_y = 16.0\,\text{kN}$.

7.90 $A_x = 0$, $A_y = -40.0\,\text{kip}$, $B_y = 40.0\,\text{kip}$.

7.92 $A_x = 0$, $A_y = 6.08\,\text{kip}$, $B_y = 4.92\,\text{kip}$.

7.94 $C_x = 0$, $C_y = 12.0\,\text{kN}$, $M_C = -24.0\,\text{kN·m}$.

7.96 $A_x = 0$, $A_y = -80\,\text{kip}$, $C_y = 80\,\text{kip}$.

7.98 $A_x = 0$, $A_y = w_1 a + w_2(L - a)$, $M_A = \frac{1}{2}w_1 a^2 + \frac{1}{2}w_2(L^2 - a^2)$.

7.100 $a = 0.524\,\text{kN/m}$, $b = 1.21\,\text{kN/m}^2$, $c = -0.0556\,\text{kN/m}^3$, $F = 23.0\,\text{kN}$, $\bar{x} = 4.05\,\text{m}$.

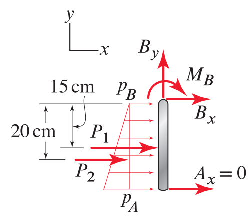
7.102 $k_t = 87.71$ kN·m/degree.

7.104 $A_x = 0$, $A_y = 0$, $A_z = W$, $M_{Ax} = -WR(1 - \frac{2}{\pi})$, $M_{Ay} = -\frac{2}{\pi}WR$, $M_{Az} = 0$.

7.106 $T = \gamma d^3$.

7.108 $T = 39.0\,\text{lb}$.

7.110 $\theta_0 = 0.235\,\text{rad} = 13.5°$.



7.112 $T_{BC} = 13{,}333$ lb, $T_{DF} = 12{,}000$ lb.

7.114 **(a)** $T = 40.7\,\text{lb}$; **(b)** $T = 323\,\text{lb}$.

7.116 $T_B = 414\,\text{N}$, $T_C = 414\,\text{N}$, $T_D = 684\,\text{N}$.

7.118 $F_{EG} = 381\,\text{lb}$.

7.120 $(\bar{x}, \bar{y}) = (4.487, 8.153)\,\text{cm}$.

7.122 $(\bar{x}, \bar{y}) = (0, 20.2)\,\text{mm}$.

7.124 $(\bar{x}, \bar{y}) = (\frac{56}{25}, 1)\,\text{m}$.

7.126 $(\bar{x}, \bar{y}, \bar{z}) = (34.7, 0, 0)\,\text{mm}$.

7.128 **(a)** Let $\rho_o = 0.002\,\text{g/mm}^3$, $\rho_i = 0.003\,\text{g/mm}^3$, $\bar{x} = \frac{\int_0^{6\,\text{mm}} x\{\rho_i \pi(2-\frac{1}{6}x)^2 + \rho_o \pi[(3+\frac{1}{6}x)^2 - (2-\frac{1}{6}x)^2]\}\,dx}{\int_0^{6\,\text{mm}} \{\rho_i \pi(2-\frac{1}{6}x)^2 + \rho_o \pi[(3+\frac{1}{6}x)^2 - (2-\frac{1}{6}x)^2]\}\,dx}$, $\bar{y} = 0$, $\bar{z} = 0$; **(b)** $(\bar{x}, \bar{y}, \bar{z}) = (3.20, 0, 0)\,\text{mm}$.

7.130 $\bar{x} = \frac{4}{3}\,\text{m}$.

7.132 **(a)** $\bar{x} = \frac{\int_0^{1\,\text{cm}} x\pi(1+x^2)^2\,dx}{\int_0^{1\,\text{cm}} \pi(1+x^2)^2\,dx}$, $\bar{y} = \bar{z} = 0$; **(b)** $\bar{x} = \frac{5}{8}\,\text{cm}$.

7.134 **(a)** $\bar{x} = \frac{\int_{-1\,\text{km}}^{2\,\text{km}} x\sqrt{1+4x^2}}{\int_{-1\,\text{km}}^{2\,\text{km}} \sqrt{1+4x^2}}$, $\bar{y} = \frac{\int_{-1\,\text{km}}^{2\,\text{km}} x^2\sqrt{1+4x^2}}{\int_{-1\,\text{km}}^{2\,\text{km}} \sqrt{1+4x^2}}$; **(b)** $(\bar{x}, \bar{y}) = (0.801, 1.48)\,\text{km}$.

7.136 $(\bar{x}, \bar{y}) = (42.00, -11.03)\,\text{in.}$, $A_x = -508.6\,\text{lb}$, $A_y = 0$, $B_x = 508.6\,\text{lb}$, $B_y = 218.0\,\text{lb}$.

7.138 $V = \frac{4\pi}{3}r^3$, $A = 4\pi r^2$.

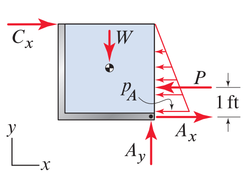
7.140 $V = 3180\,\text{cm}^3$, $A = 867\,\text{cm}^2$.

7.142 $A_x = 0$, $A_y = 1700\,\text{lb}$, $B_y = 1300\,\text{lb}$.

7.144 $B_y = 640\,\text{lb}$, $C_x = 0$, $C_y = 1460\,\text{lb}$ where pin C is located 6 ft from the left-hand end of the beam.

7.146 $A_x = 0$, $A_y = 2.17\,\text{kN}$, $C_y = 3.83\,\text{kN}$ where roller C is located 2 m from the right-hand end of the beam.

7.148 $A_x = -46.8\,\text{lb}$, $A_y = 281\,\text{lb}$, $C_x = 187\,\text{lb}$.



7.150 $d = -12.5\,\text{mm}$.

Chapter 8

8.2 $N_H = -34.7\,\text{lb}$, $V_H = -197\,\text{lb}$, $M_H = 1180\,\text{in.·lb}$, $N_J = -480\,\text{lb}$, $V_J = 0$, $M_J = 0$.

8.4 $N_E = 200\,\text{lb}$, $V_E = 346\,\text{lb}$, $M_E = 0$, $N_F = 200\,\text{lb}$, $V_F = 346\,\text{lb}$, $M_F = -8310\,\text{in.·lb}$

8.6 $N_F = -3.20\,\text{kN}$, $V_F = 4.27\,\text{kN}$, $M_F = 0$, $N_G = -3.20\,\text{kN}$, $V_G = 4.27\,\text{kN}$, $M_G = 10.7\,\text{kN·m}$, $N_H = -0.800\,\text{kN}$, $V_H = 1.07\,\text{kN}$, $M_H = 10.7\,\text{kN·m}$, $N_I = -0.800\,\text{kN}$, $V_I = 1.07\,\text{kN}$, $M_I = 13.3\,\text{kN·m}$.

8.8 $N_F = -11.2\,\text{kN}$, $V_F = 1.60\,\text{kN}$, $M_F = 0$, $N_G = -11.2\,\text{kN}$, $V_G = 1.60\,\text{kN}$, $M_G = 4.00\,\text{kN·m}$, $N_H = -8.80\,\text{kN}$, $V_H = -1.60\,\text{kN}$, $M_H = 4.00\,\text{kN·m}$, $N_I = -8.80\,\text{kN}$, $V_I = -1.60\,\text{kN}$, $M_I = 0$.

8.10 $N_D = 0$, $V_D = 100\,\text{lb}$, $M_D = 0$, $N_E = 0$, $V_E = 100\,\text{lb}$, $M_E = -150\,\text{in.·lb}$, $N_F = -70.7\,\text{lb}$, $V_F = 70.7\,\text{lb}$, $M_F = -238\,\text{in.·lb}$.

8.12 $N_H = -2.00\,\text{kN}$, $V_H = 2.00\,\text{kN}$, $M_H = 0$, $N_I = -2.00\,\text{kN}$, $V_I = 2.00\,\text{kN}$, $M_I = -5.60\,\text{kN·m}$.

8.14 $N_L = -2.00\,\text{kN}$, $V_L = -2.00\,\text{kN}$, $M_L = -3.20\,\text{kN·m}$, $N_O = -2.00\,\text{kN}$, $V_O = -2.00\,\text{kN}$, $M_O = 0$.

8.16 $N_R = -5.83\,\text{kN}$, $V_R = 0\,\text{kN}$, $M_R = 0$, $N_A = -4.00\,\text{kN}$, $V_A = 0$, $M_A = 4.20\,\text{kN·m}$.

8.18 $N_H = -400\,\text{lb}$, $V_H = -693\,\text{lb}$, $M_H = -1390\,\text{ft·lb}$, $N_I = -400\,\text{lb}$, $V_I = -693\,\text{lb}$, $M_I = 0$.

8.20 $N_L = 400\,\text{lb}$, $V_L = -693\,\text{lb}$, $M_L = 1390\,\text{ft·lb}$, $N_M = 0$, $V_M = -800\,\text{lb}$, $M_M = 0$.

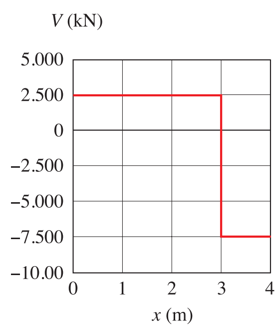
8.22 Essay-type answer.

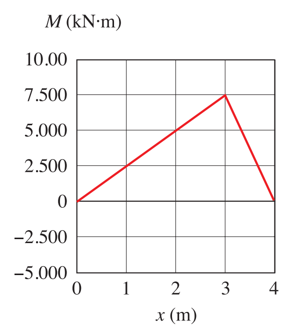
8.24 $V_{Ax} = 0$, $V_{Ay} = 150\,\text{lb}$, $N_{Az} = 0$, $M_{Ax} = -2400\,\text{in.·lb}$, $M_{Ay} = 0$, $M_{Az} = 3600\,\text{in.·lb}$.

8.26 $N_{Bx} = 0$, $V_{By} = 0$, $V_{Bz} = 120\,\text{N}$, $M_{Bx} = 8.40\,\text{N·m}$, $M_{By} = -12.6\,\text{N·m}$, $M_{Bz} = 0$.

8.28 $V_{Dx} = 0$, $N_{Dy} = 0$, $V_{Dz} = 120\,\text{N}$, $M_{Dx} = 13.8\,\text{N·m}$, $M_{Dy} = -14.4\,\text{N·m}$, $M_{Dz} = 0$.

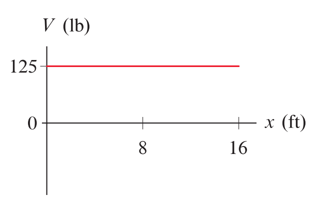
8.30 $V = 2.50\,\text{kN}$, $M = (2.50\,\text{kN})x$ for $0 \le x \le 3\,\text{m}$; $V = -7.50\,\text{kN}$, $M = (7.50\,\text{kN})(4\,\text{m} - x)$ for $3\,\text{m} \le x \le 4\,\text{m}$.

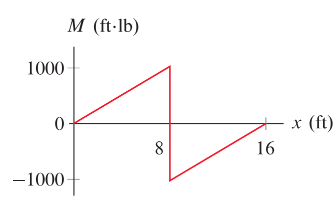




8.32 **(a)** $V = P$, $M = Px$ for $0 \le x \le \frac{1}{3}L$; $V = 0$, $M = \frac{1}{3}PL$ for $\frac{1}{3}L \le x \le \frac{2}{3}L$; $V = -P$, $M = P(L - x)$ for $\frac{2}{3}L \le x \le L$; **(b)** Essay-type answer.

8.34 $V = 125\,\text{lb}$, $M = (125\,\text{lb})\,x$ for $0 \le x \le 8\,\text{ft}$; $V = 125\,\text{lb}$, $M = (-125\,\text{lb})(16\,\text{ft} - x)$ for $8\,\text{ft} \le x \le 16\,\text{ft}$.

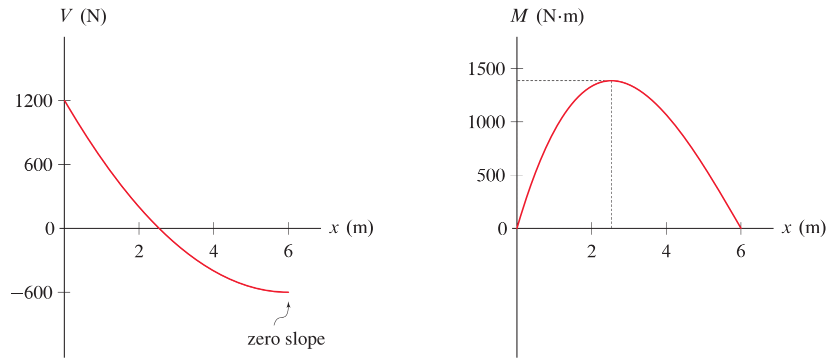




8.36 $V = 1000\,\text{lb}$, $M = (-1000\,\text{lb})(20\,\text{ft} - x)$.

8.38 $V = (-8\,\text{kN/m})\,x$, $M = (-4\,\text{kN/m})\,x^2$.

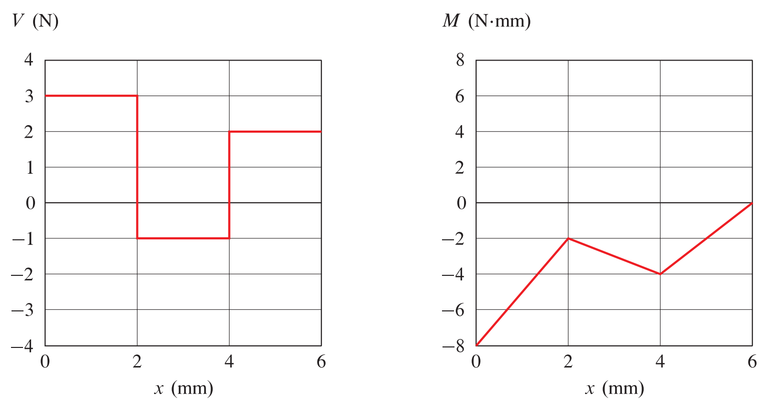
8.40 $V = 1200\,\text{N} - (600\,\text{N/m})\,x + (50\,\text{N/m}^2)\,x^2$, $M = (1200\,\text{N})\,x - (300\,\text{N/m})\,x^2 + (16.7\,\text{N/m}^2)\,x^3$.



8.42 Essay-type answer.

8.44 $w_0 = 550.5\,\text{lb/ft}$.

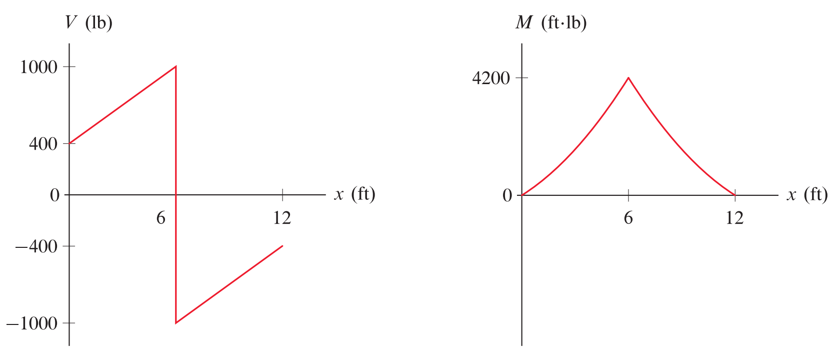
8.46 $V = 3.00\,\text{N}$, $M = -8.00\,\text{N}\cdot\text{mm} + (3.00\,\text{N})\,x$ for $0 \le x \le 2\,\text{mm}$; $V = -1.00\,\text{N}$, $M = -(1.00\,\text{N})\,x$ for $2\,\text{mm} \le x \le 4\,\text{mm}$; $V = 2.00\,\text{N}$, $M = -12\,\text{N}\cdot\text{mm} + (2.00\,\text{N})\,x$ for $4\,\text{mm} \le x \le 6\,\text{mm}$.



8.48 $V = 3.00\,\text{N}$, $M = -8.00\,\text{N}\cdot\text{mm} + (3.00\,\text{N})\,x$ for $0 \le x \le 2\,\text{mm}$; $V = 0$, $M = 0$ for $2\,\text{mm} \le x \le 6\,\text{mm}$.

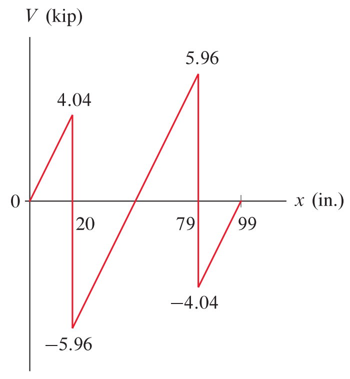
8.50 Essay-type answer.

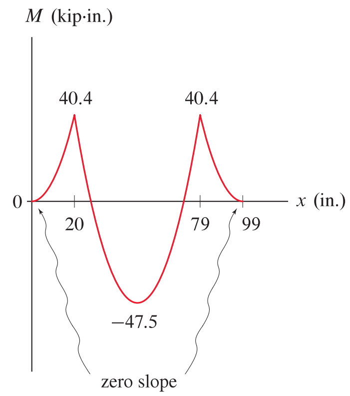
8.52 $V = -100\,\text{lb/ft}(6\,\text{ft} - x) + 1000\,\text{lb}$, $M = -50\,\text{lb/ft}[(12\,\text{ft})x - x^2] + (1000\,\text{lb})\,x$ for $0 \le x \le 6\,\text{ft}$; $V = -100\,\text{lb/ft}(6\,\text{ft} - x) - 1000\,\text{lb}$, $M = -50\,\text{lb/ft}[(12\,\text{ft})x - x^2] + (1000\,\text{lb})(12\,\text{ft} - x)$ for $6\,\text{ft} \le x \le 12\,\text{ft}$.



8.54 $V = 1000\,\text{N}$, $M = (1000\,\text{N})\,x$ for $0 \le x \le 1\,\text{m}$; $V = 100\,\text{N}$, $M = (100\,\text{N})(9\,\text{m} + x)$ for $1\,\text{m} \le x \le 2\,\text{m}$; $V = -1100\,\text{N}$, $M = (1100\,\text{N})(3\,\text{m} - x)$ for $2\,\text{m} \le x \le 3\,\text{m}$.

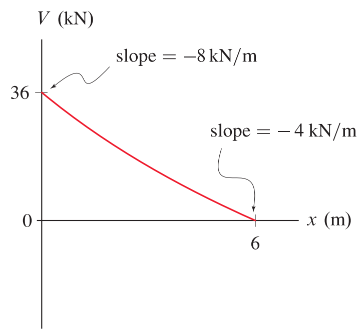
8.56 $V = (0.202\,\text{kip/in.})\,x$, $M = (0.101\,\text{kip/in.})x^2$ for $0 \le x \le 20\,\text{in.}$; $V = -10.0\,\text{kip} + (0.202\,\text{kip/in.})\,x$, $M = 200\,\text{kip}\cdot\text{in.} - (10.0\,\text{kip})\,x + (0.101\,\text{kip/in.})x^2$ for $20\,\text{in.} \le x \le 79\,\text{in.}$; $V = (-0.202\,\text{kip/in.})(99.0\,\text{in.} - x)$, $M = (0.101\,\text{kip/in.})(99.0\,\text{in.} - x)^2$ for $79\,\text{in.} \le x \le 99\,\text{in.}$

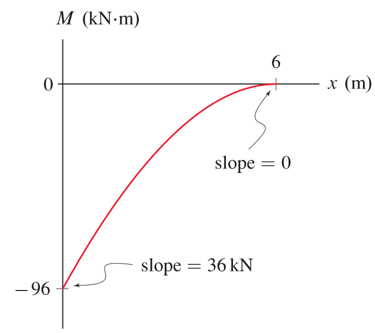




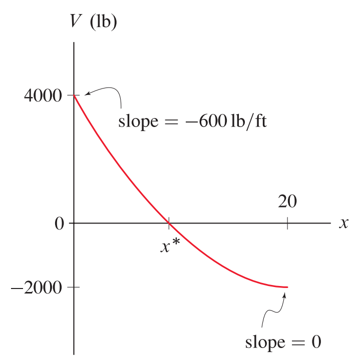
8.58 $V = (-8\,\text{kN/m})\,x$, $M = (-4\,\text{kN/m})\,x^2$.

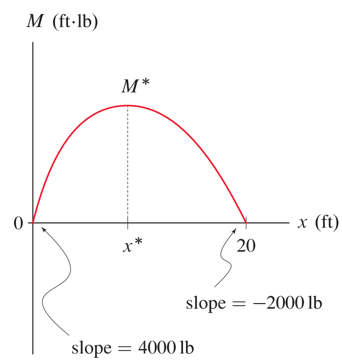
8.60 $V = 36\,\text{kN} - (8\,\text{kN/m})\,x + (\frac{1}{3}\,\text{kN/m}^2)\,x^2$, $M = -96\,\text{kN·m} + (36\,\text{kN})\,x - (4\,\text{kN/m})\,x^2 + (\frac{1}{9}\,\text{kN/m}^2)\,x^3$.





8.62 $V = 4000\,\text{lb} - (15\,\text{lb/ft})[(40\,\text{ft})x - x^2]$, $M = (4000\,\text{lb})\,x - (5\,\text{lb/ft}^2)[(60\,\text{ft})x^2 - x^3]$, $M_{max} = 15{,}400\,\text{ft·lb}$ at $x = 8.45\,\text{ft}$.

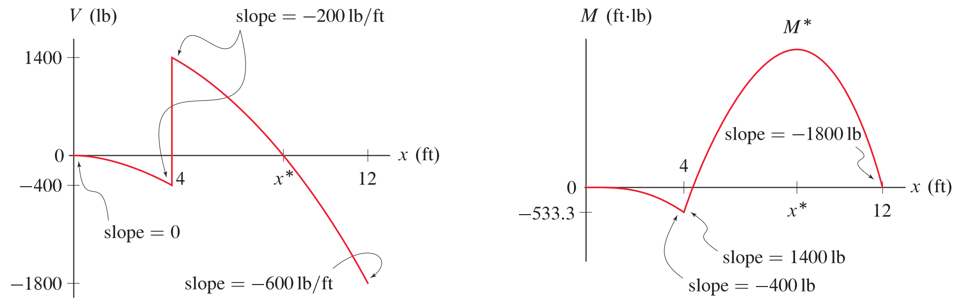




8.64 $V = \frac{1}{6}w_0L - w_0(x - \frac{1}{L}x^2)$, $M = w_0(\frac{L}{6}x - \frac{1}{2}x^2 + \frac{1}{3L}x^3)$, $M_{max} = (0.0160)w_0L^2$ at $x = (0.211)L$ and $M_{max} = (-0.0160)w_0L^2$ at $x = (0.789)L$.

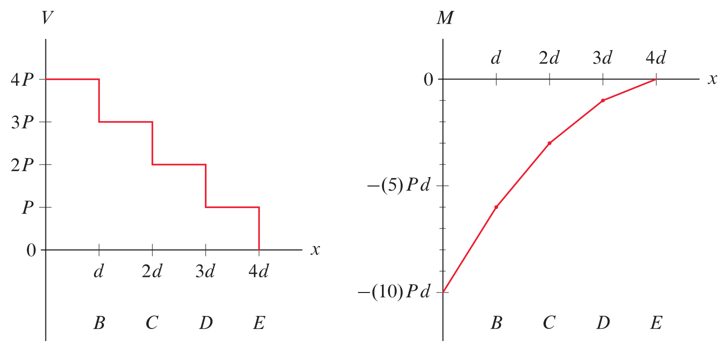
8.66 $V = 2P$, $M = -\frac{3}{2}PL + 2Px$ for $0 \le x \le \frac{L}{2}$; $V = P$, $M = -\frac{1}{2}PL + P(x - \frac{1}{2}L)$ for $\frac{L}{2} \le x \le L$.

8.68 $V = (-25\,\text{lb/ft}^2)\,x^2$, $M = (-\frac{25}{3}\,\text{lb/ft}^2)\,x^3$ for $0 \le x \le 4\,\text{ft}$; $V = 1800\,\text{lb} - (25\,\text{lb/ft}^2)\,x^2$, $M = -7200\,\text{ft·lb} + (1800\,\text{lb})\,x - (\frac{25}{3}\,\text{lb/ft}^2)\,x^3$ for $4\,\text{ft} \le x \le 12\,\text{ft}$.

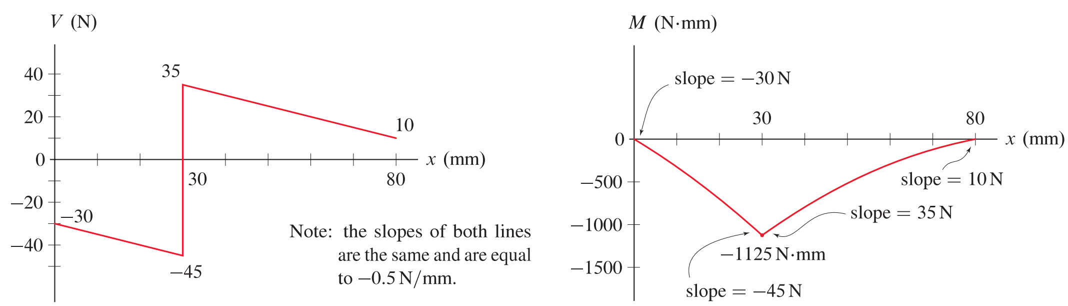


8.70 $V = (-1.00\,\text{kN/m})\,x$, $M = (-0.500\,\text{kN/m})\,x^2$ for $0 \le x \le 1.3\,\text{m}$; $V = -6.86\,\text{kN} - (1.00\,\text{kN/m})(x - 1.30\,\text{m})$, $M = 7.22\,\text{kN·m} - (5.56\,\text{kN})\,x - (0.500\,\text{kN/m})\,x^2$ for $1.3\,\text{m} \le x \le 4\,\text{m}$; $V = -14.0\,\text{kN} - (1.00\,\text{kN/m})(x - 4.00\,\text{m})$, $M = 25.0\,\text{kN·m} - (10.0\,\text{kN})\,x - (0.500\,\text{kN/m})\,x^2$ for $4\,\text{m} \le x \le 5.5\,\text{m}$.

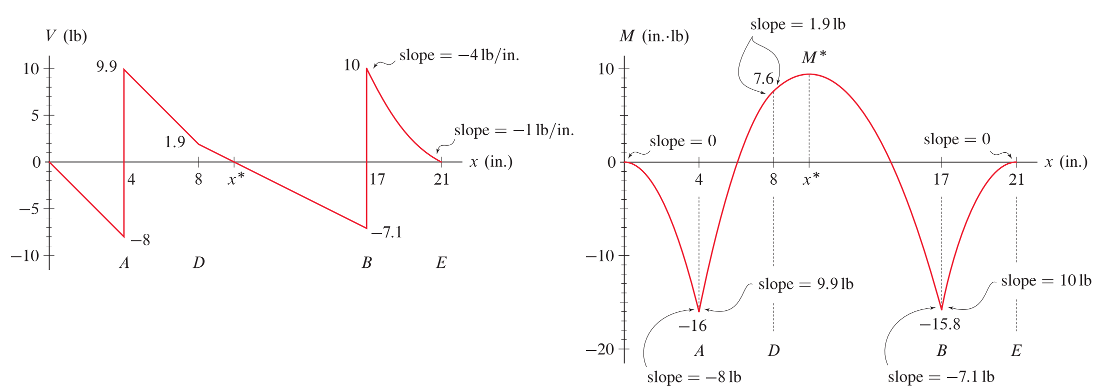
8.72 $V_{\text{max}} = 4P$ at $x = 0$, $M_{\text{max}} = -10Pd$ at $x = 0$.



8.74 $V_{\text{max}} = -45.0\,\text{N}$ just to the left of $x = 30\,\text{mm}$, $M_{\text{max}} = -1130\,\text{N·mm}$ at $x = 30\,\text{mm}$.



8.76 $V_{\text{max}} = 10.0\,\text{lb}$ just to the right of $x = 17\,\text{in.}$, $M_{\text{max}} = -16.0\,\text{in.·lb}$ at $x = 4\,\text{in.}$

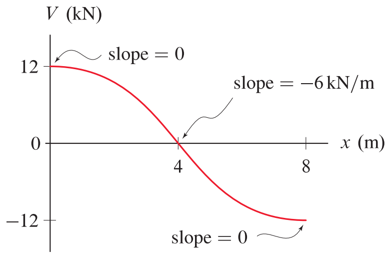


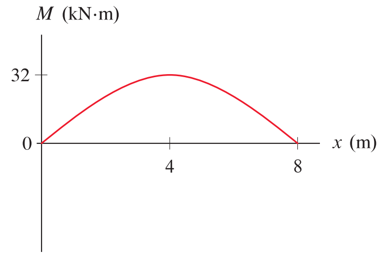
8.78 Beam 1: Shear diagram (b), Moment diagram (g); Beam 2: Shear diagram (a), Moment diagram (g); Beam 3: Shear diagram (d), Moment diagram (f).

8.80 $N_F = -6.19\,\text{kip}$, $V_F = 0.940\,\text{kip}$, $M_F = 0$, $N_G = -6.19\,\text{kip}$, $V_G = 0.940\,\text{kip}$, $M_G = 4.00\,\text{kip·ft}$.

8.82 $N_E = -833\,\text{N}$, $V_E = 833\,\text{N}$, $M_E = 0$, $N_F = -1180\,\text{N}$, $V_F = 0$, $M_F = -69.0\,\text{N·m}$, $N_G = 833\,\text{N}$, $V_G = -833\,\text{N}$, $M_G = 0$.

8.84 $V = 12\,\text{kN} - (0.750\,\text{kN/m}^2)\,x^2$, $M = (12\,\text{kN})\,x - (0.250\,\text{kN/m}^2)\,x^3$ for $0 \le x \le 4\,\text{m}$; $V = 36\,\text{kN} - (12\,\text{kN/m})\,x + (0.750\,\text{kN/m}^2)\,x^2$, $M = -32\,\text{kN·m} + (36\,\text{kN})\,x - (6\,\text{kN/m})\,x^2 + (0.250\,\text{kN/m}^2)\,x^3$ for $4\,\text{m} \le x \le 8\,\text{m}$.

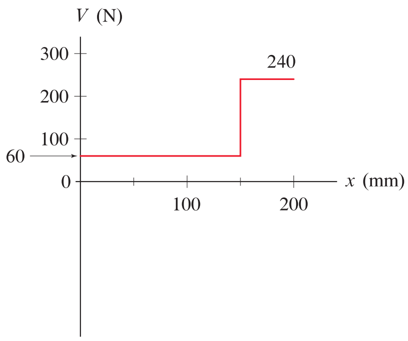


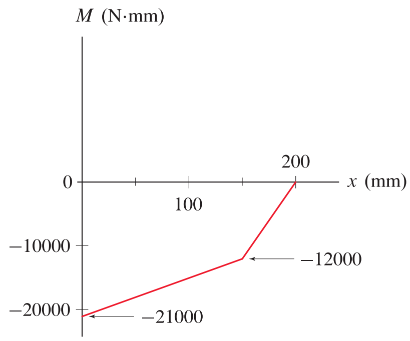


8.86 $V = 12\,\text{kN} - (0.750\,\text{kN/m}^2)\,x^2$, $M = (12\,\text{kN})\,x - (0.250\,\text{kN/m}^2)\,x^3$ for $0 \le x \le 4\,\text{m}$; $V = 36\,\text{kN} - (12\,\text{kN/m})\,x + (0.750\,\text{kN/m}^2)\,x^2$, $M = -32\,\text{kN·m} + (36\,\text{kN})\,x - (6\,\text{kN/m})\,x^2 + (0.250\,\text{kN/m}^2)\,x^3$ for $4\,\text{m} \le x \le 8\,\text{m}$; see V and M plots for Prob. 8.82.

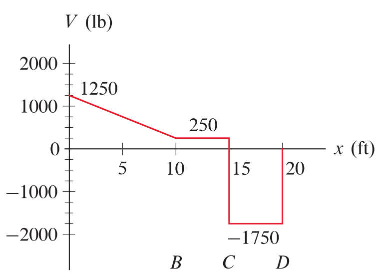
8.88 $V = 60\,\text{N}$, $M = -12{,}000\,\text{N·mm} + (60\,\text{N})\,x$.

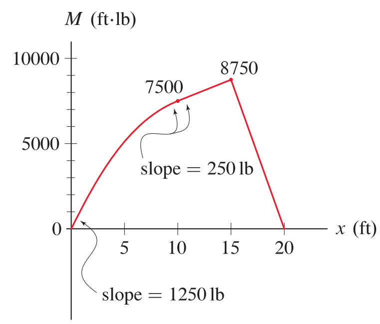
8.90 $V = 60\,\text{N}$, $M = -21{,}000\,\text{N·mm} + (60\,\text{N})\,x$ for $0 \le x \le 150\,\text{mm}$; $V = 240\,\text{N}$, $M = -48{,}000\,\text{N·mm} + (240\,\text{N})\,x$ for $150\,\text{mm} \le x \le 200\,\text{mm}$.



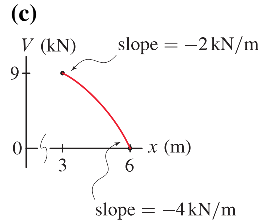


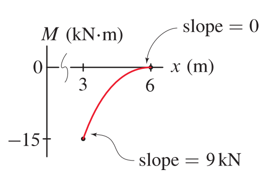
8.92 $V_{max} = -1750\,\text{lb}$ for $15\,\text{ft} \le x \le 20\,\text{ft}$, $M_{max} = 8750\,\text{ft·lb}$ at $x = 15\,\text{ft}$.



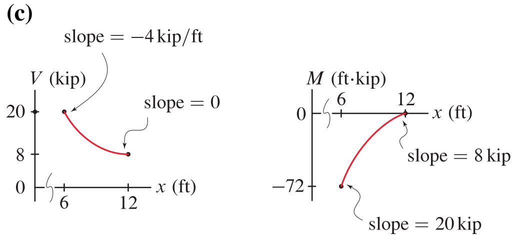


8.94 **(a)** $V = -4\,\text{kN} - (\frac{1}{3}\,\text{kN/m}^2)\,x^2$; **(b)** $M = (-4\,\text{kN})\,x - (\frac{1}{9}\,\text{kN/m}^2)\,x^3$; **(c)** $V_{max} = 9.00\,\text{kN}$ at $x = 3\,\text{m}$, $M_{max} = -15.0\,\text{kN·m}$ at $x = 3\,\text{m}$;
(c)

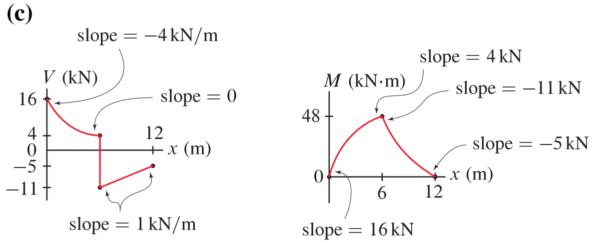




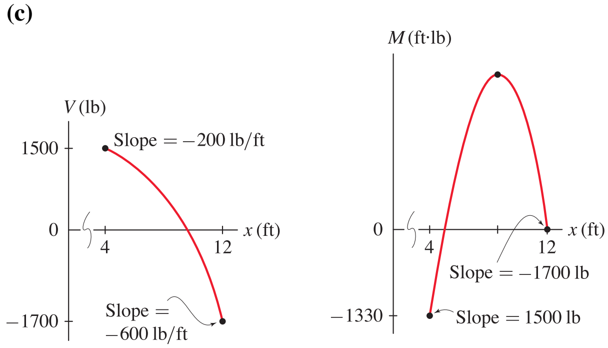
8.96 **(a)** $M = (-2\,\text{kip/ft})\,x^2$; **(b)** $V = 56\,\text{kip} - (8\,\text{kip/ft})\,x + (\frac{1}{3}\,\text{kip/ft}^2)\,x^2$; **(c)** $V_{\max} = 20.0\,\text{kip}$ at $x = 6\,\text{ft}$, $M_{\max} = -72.0\,\text{ft·kip}$ at $x = 6\,\text{ft}$;
(c)



8.98 **(a)** $M = 132\,\text{kN}\cdot\text{m} - (17\,\text{kN})\,x + (0.5\,\text{kN/m})\,x^2$; **(b)** $V = 16\,\text{kN} - (4\,\text{kN/m})\,x + (\frac{1}{3}\,\text{kN/m}^2)\,x^2$;
(c)



8.100 **(a)** $V = \big(-25\,\text{lb/ft}^2\big)x^2$; **(b)** $M = -800\,\text{ft·lb} - \big(25\,\text{lb/ft}^2\big)x^3/3$;
(c)



Chapter 9

9.2 $N = 52.1\,\text{lb}$, $F = 10.3\,\text{lb}$, the box remains at rest on the ramp.

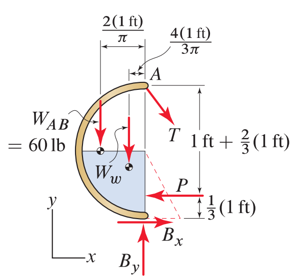
9.4 $P = 471.4\,\text{N}$.

9.6 $\theta = \tan^{-1}\mu$.

9.8 $h = 60.0\,\text{cm}$.

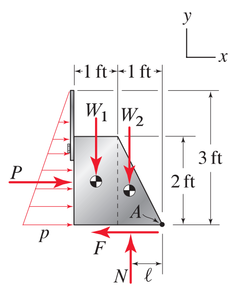
9.10 $N = 1.43\times10^6\,\text{lb}$, $F = 8.58\times10^4\,\text{lb}$.

9.12 $\mu \geq 0.0939$.



9.14 The dam will not slide or tip when the reservoir is completely full.

9.16 The dam will not tip and will fail by sliding.



9.18 $P = 47.4\,\text{N}$.

9.20 $T = 1.940\,\text{N}$.

9.22 **(a)** $\mu = 1.103$, safe from tipping; **(b)** $\mu = 0.3540$, safe from tipping; **(c)** $\mu = 0.2680$, safe from tipping.

9.24 **(a)** $\mu_{\text{min}} = 0.289$; **(b)** The answer to Part (a) will change, essay-type answer; **(c)** The answer to Part (a) does not change, essay-type answer.

9.26 $P_1 = 0.6344\,\text{lb}$.

9.28 $Q = 0.0915\,\text{lb}$.

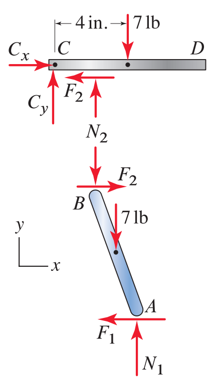
9.30 $\mu_s = 0.750$.

9.32 $P = 0.900\,\text{lb}$ will cause all books to slide together on the table.

9.34 $\mu_A = \mu_B = 0.6867$.

9.36 Nine books may be lifted.

9.38 $\mu_s = 0.417$.



9.40 $Q = 7.70\,\text{lb}$.

9.42 $P = 10.6\,\text{N}$.

9.44 The truck is not capable of pulling the dumpster.

9.46 $P = 7.00\,\text{kN}$.

9.48 $\mu_s = \frac{5}{3}$.

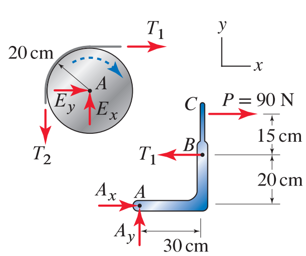
9.50 $T_{BD} = 789.9\,\text{lb}$.

9.52 **(a)** $P = 4.56\,\text{N}$; **(b)** $T_{CD} = 6.58\,\text{N}$, essay-type answer.

9.54 **(a)**, **(b)**, & **(c)**: 73.0 lb.

9.56 $8.494\,\text{lb} \le P \le 16.95\,\text{lb}$.

9.58 $M_A = 23.1\,\text{N·m}$.



9.60 $M_A = 575$ in.·lb.

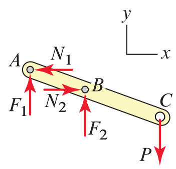
9.62 **(a)** $P = 14.1$ N; **(b)** $P = 4.27$ N.

9.64 $W = 35.3$ lb.

9.66 $W_B = 53.8$ lb, surface C will stick while motion is impending at A and B.

9.68 **(a)** $T_{CD} = 89.86$ lb; **(b)** The assumption of no tipping is correct.

9.70 $\mu = 0.0741$.



9.72 $N = 156$ kN, $F = 14.7$ kN, $\mu = 0.0943$, N and F are located 0.730 m to the left of point A.

9.74 $h = 9$ mm.

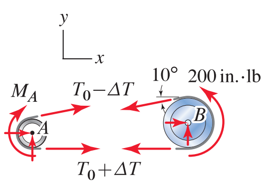
9.76 $P = 1.60$ lb, the roll of paper will tip.

9.78 **(a)** It is not possible to descend the hill with uniform speed; **(b)** It is possible to descend the hill with uniform speed, $Q = 16.03$ lb.

9.80 $P = 56.2$ lb, slip is impending at E and there is no slip at B and C.

9.82 $W = 4402$ N, $M_A = (5532\text{ N})\, r_A$ where r_A is the radius of pulley A.

9.84 $T_0 = 57.4$ lb.



Chapter 10

10.2 Essay-type answer.

10.4 $I_x = 568\, a^4$, $I_y = 328\, a^4$.

10.6 $I_x = 0.0404$ in.^{4}, $I_y = 0.0570$ in.^{4}.

10.8 $I_x = \frac{1}{12} bh^3$, $I_y = \frac{1}{12} hb^3$.

10.10 Answer provided in problem statement.

10.12 $I_y = \frac{\pi}{16} r_0^4$, $J_O = \frac{\pi}{8} r_o^4$, essay-type answer.

10.14 $J_A = \frac{\pi}{4} r_o^4$.

10.16 Essay-type answer.

10.18 **(a)** $I_x = 2.74$ mm^4; **(b)** $I_y = 11.0$ mm^4.

10.20 **(a)** $I_x = 0.305$ mm^4; **(b)** $I_y = 1.60$ mm^4.

10.22 **(a)** $I_x = 0.500$ in.^{4}; **(b)** $I_y = 0.375$ in.^{4}.

10.24 $c_1 = b/\sqrt{a}$, $c_2 = b/a^3$, $I_x = \frac{1}{10} ab^3$.

10.26 $I_x = 0.305$ mm^4.

10.28 $I_x = 4.64\times10^7$ mm^4, $I_y = 4.58\times10^6$ mm^4, $k_x = 105$ mm, $k_y = 33.1$ mm.

10.30 $I_x = 117$ in.^{4}, essay-type answer.

10.32 $k_x = 23.1$ in.

10.34 For the rectangular cross section: $I_x = 108$ in.^{4}, $I_y = 108$ in.^{4}; For the I cross section: $I_x = 428$ in.^{4}, $I_y = 76.0$ in.^{4}.

10.36 $I_x = 4.06\times10^5$ mm^4, $I_y = 1.83\times10^5$ mm^4.

10.38 $I_x = 37.6\,\text{in.}^4$, $I_y = 10.9\,\text{in.}^4$.

10.40 **(a)** $I_{x_1} = 1820\,\text{mm}^4$; **(b)** $I_{x_2} = 2550\,\text{mm}^4$.

10.42 **(a)** $d = 4.00$ in.; **(b)** $I_x = 128\,\text{in.}^4$; **(c)** $I_y = 704\,\text{in.}^4$.

10.44 **(a)** $d = 2.00$ mm; **(b)** $I_x = 88.0\,\text{mm}^4$; **(c)** $I_y = 64.0\,\text{mm}^4$.

10.46 **(a)** $d = 65.0$ mm; **(b)** $I_x = 1.45\times10^6\,\text{mm}^4$; **(c)** $I_y = 1.13\times10^5\,\text{mm}^4$.

10.48 Answer provided in problem statement.

10.50 $I_y = \frac{1}{4}mr^2$ where $m = \rho\pi r^2 t$.

10.52 $I_y = m(\frac{1}{4}R^2 + \frac{1}{3}L^2)$ where $m = \rho\pi R^2 L$.

10.54 $I_z = \frac{3}{5}m(\frac{1}{4}R^2 + L^2)$ where $m = \frac{1}{3}\rho\pi R^2 L$.

10.56 $I_y = \frac{3}{5}m(\frac{1}{3}b^2 + h^2)$ where $m = \frac{4}{3}\rho abh$.

10.58 Essay-type answer.

10.60 **(a)** $I_x = \frac{1}{2}\int_0^{r/2} \frac{\rho_0}{2}\pi(r^2 - x^2)^2\,dx + \frac{1}{2}\int_{r/2}^{r} \rho_0\pi(r^2 - x^2)^2\,dx$; **(b)** $I_x = \frac{103}{640}\pi r^5 \rho_0$.

10.62 $I_x = 4.28\times10^{-5}\,\text{slug}\cdot\text{in.}^2$

10.64 $I_y = \frac{1}{3}ma^2$ where $m = \frac{1}{2}\rho\pi ha^2$.

10.66 **(a)** $I_y = \int_0^L \frac{\rho\pi}{4}R^4[(\frac{x}{L})^{4/3} - (\frac{x}{2L})^4]\,dx + \int_0^L \rho\pi R^2 x^2[(\frac{x}{L})^{2/3} - (\frac{x}{2L})^2]\,dx$; **(b)** $I_y = m\frac{16464\,L^2 + 7689\,R^2}{38192}$ where $m = \frac{31}{60}\rho\pi L R^2$.

10.68 **(a)** $I_x = 2\int_0^L \rho t_0(2 - \frac{x}{L})\pi\left(\frac{Rx}{L}\right)^3\sqrt{1 + \frac{R^2}{L^2}}\,dx$; **(b)** $I_x = \frac{9}{20}mR^2$ where $m = \frac{4}{3}\rho t_0 \pi RL\sqrt{1 + \frac{R^2}{L^2}}$.

10.70 $I_y = 1.50\times10^{-3}\,\text{kg}\cdot\text{cm}^2$.

10.72 $I_x = \frac{25}{56}mR^2$ where $m = \frac{7}{12}\rho\pi R^3$.

10.74 $I_z = \frac{7}{16}mR^2$ where $m = \frac{7}{12}\rho\pi R^3$.

10.76 $I_{Oz} = 0.0217\,\text{slug}\cdot\text{ft}^2$, essay-type answer.

10.78 $I_y = \frac{1}{3}m(a^2 + c^2)$.

10.80 $I_B = 20{,}700\,\text{kg}\cdot\text{mm}^2$.

10.82 $I_A = 9.24\times10^{-4}\,\text{slug}\cdot\text{in.}^2$.

10.84 $I_x = 0.497\,\text{slug}\cdot\text{in.}^2$.

10.86 $I_B = 0.0778\,\text{kg}\cdot\text{m}^2$.

10.88 $I_x = 1.61\,\text{slug}\cdot\text{in.}^2$.

10.90 $I_z = 0.627\,\text{slug}\cdot\text{in.}^2$.

10.92 $I_y = 3.53\,\text{slug}\cdot\text{in.}^2$.

10.94 $I_y = 5.10\times10^{-3}\,\text{slug}\cdot\text{ft}^2$.

10.96 $J_O = \frac{\pi}{4}(r_o^4 - r_i^4)$.

10.98 **(a)** $I_y = \int_0^{4\,\text{m}} x^2(\sqrt{x} - \frac{1}{4}x)\,dx$; **(b)** $I_y = 20.6\,\text{m}^4$.

10.100 $c_1 = 6$, $c_2 = -\frac{1}{3}$, $c_3 = 1$; **(a)** $I_y = \int_0^{9\,\text{in.}} x^2(6 - \frac{1}{3}x - \sqrt{x})\,dx$; **(b)** $I_y = 286\,\text{in.}^4$.

10.102 **(a)** $I_y = 2\int_0^{1\,\text{in.}} x^2(x - 1)^2\,dx$; **(b)** $I_y = 0.0667\,\text{in.}^4$.

10.104 $I_x = 2.98\times10^6\,\text{mm}^4$, $I_y = 3.25\times10^5\,\text{mm}^4$.

10.106 **(a)** $d = 1.183$ in.; **(b)** $I_x = 5.56\,\text{in.}^4$.

10.108 $I_z = \frac{3}{10}mr^2$ where $m = \frac{1}{3}\rho\pi r^2 h$.

10.110 $I_x = 1700\,\text{kg}\cdot\text{mm}^2$.

10.112 $I_z = 3040\,\text{kg}\cdot\text{mm}^2$.

10.114 $I_x = 0.0113\,\text{kg}\cdot\text{mm}^2$.

10.116 $I_x = \frac{1}{2}\int_0^h \rho_1\pi x^2\,dx + \frac{1}{2}\int_h^{2h} \rho_2\pi x^2\,dx$.

10.118 $I_y = 1.79\times10^5\,\text{kg}\cdot\text{m}^2$.

10.120 **(a)** $I_x = 1.43\times10^8\,\text{mm}^4$; **(b)** $I_x = 5.45\times10^5\,\text{kg}\cdot\text{mm}^2$.

10.122 $I_x = 13.3\,\text{slug}\cdot\text{in.}^2$.

10.124 $I_z = 16.7\,\text{slug}\cdot\text{in.}^2$.