Answers to Selected Even-Numbered Problems

NOTE TO INSTRUCTORS CONSIDERING ADOPTION: Additional content (e.g., FBDs, shear and moment diagrams, etc.) is in the process of being added to this document. The answers reported here, along with the solutions manual, are currently being accuracy checked by several professors. This document, as well as the solutions manual, will be updated and completed by early summer, 2009. PowerPoint slides with embedded animations are also available.

We are happy to receive any questions you might have on the book or the supplements. For statics, please contact Mike Plesha at:

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If you would like a copy of the solutions manual to aid your adoption decision, then please contact the editor, Bill Stenquist, at:

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Thank you for your consideration.

The Authors

Chapter 1

1.2 Answers given in problem statement.

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

1.6 **(a)** $l = 5.02$ ft; **(b)** $m = 4.46$ slug; **(c)** $F = 20.1$ lb; **(d)** $M = 291$ in. $\cdot$ lb.

1.8 **(a)** $p = 3.63\,\text{lb/in.}^2$; **(b)** $E = 29.0\times10^6\,\text{lb/in.}^2$; **(c)** $I_{\text{area}} = 5.65\,\text{in.}^4$; **(d)** I_{mass}=109 in. $\cdot$ lb $\cdot$ s^2.

1.10 $m = 0.115$ kg.

1.12 $g_{\text{theory}} = 9.787\,\text{m/s}^2$.

1.14 $F = 2.03\times10^{14}$ N.

1.16 **(a)** $\gamma = 65.7\,\text{kN/m}^3$, $\rho = 6.70\times10^3\,\text{kg/m}^3$; **(b)** $\gamma = 20.9\,\text{kN/m}^3$, $\rho = 2.13\times10^3\,\text{kg/m}^3$; **(c)** $\gamma = 0.314\,\text{kN/m}^3$, $\rho = 32.0\,\text{kg/m}^3$; **(d)** $\gamma = 21.4\,\text{kN/m}^3$, $\rho = 2.19\times10^3\,\text{kg/m}^3$.

1.18 0.217 lb.

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

Chapter 2

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

2.4 **(a)** $\vec{R} = 6.32$ m @ $71.6°\measuredangle$; **(b)** $\vec{R} = 7.21$ m @ $-56.3°\measuredangle$; **(c)** $\vec{R} = 16.97\,\text{m}^2$ @ $45.0°\measuredangle$; **(d)** $\vec{R} = 1.41$ @ $45.0°\measuredangle$.

2.6 $\alpha = 16.0°$ or $104°$.

2.8 $F = 1.60$ kN, $\theta = 90°$.

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

2.12 $\alpha = 60°$, $F_1 = 246$ N.

2.14 **(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.

2.16 $\beta = 90°$, $F_{OC'} = 200$ lb.

2.18 $\vec{R} = (-18\,\hat{\imath} + 35\,\hat{\jmath})$ kN.

2.20 $\vec{F} = 1.60\,\hat{\jmath}$ kN.

2.22 **(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.

2.24 $\alpha = 60°$, $F_1 = 246$ N, $\vec{F}_1 = (-213\,\hat{\imath} + 123\,\hat{\jmath})$ N.

2.26 **(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.

2.28 $\vec{R} = (-93.6\,\hat{\imath} + 541\,\hat{\jmath})$ N, $|\vec{R}| = 549$ N, $\vec{R} = 549$ N @ $99.8°\measuredangle$.

2.30 $F_2/F_1 = 1.50$.

2.32 $\alpha = 33.7°$, $R = 6.42$ kN.

2.34 **(a)** Not safe; **(b)** Not safe; **(c)** Safe.

2.36 $R_x = 100$ N, $R_y = -200$ N, $R_t = -13.4$ N, $R_n = -233$ N.

2.38 **(a)** $R_x = -213$ N, $R_y = 51.7$ N; **(b)** $R_t = -187$ N, $R_n = -114$ N.

2.40 $\vec{r}_{AB} = (-20\,\hat{\imath} + 48\,\hat{\jmath})$ mm, $x_B = 165$ mm, $y_B = 48$ mm.

2.42 $\vec{r}_{AC} = (-50\,\hat{\imath} + 120\,\hat{\jmath})$ mm, $x_C = 135$ mm, $y_C = 120$ mm.

2.44 $\vec{r}_{OA} = (95\,\hat{\imath} + 56\,\hat{\jmath})$ mm, $\vec{r}_{OB} = (68\,\hat{\imath} + 92\,\hat{\jmath})$ mm, $\vec{r}_{OC} = (17\,\hat{\imath} + 160\,\hat{\jmath})$ mm, $x_B = 68$ mm, $y_B = 92$ mm.

2.46 $\vec{F} = (-4.59\,\hat{\imath} + 26.8\,\hat{\jmath} + 12.6\,\hat{k})$ lb, $\vec{Q} = (39.8\,\hat{\imath} + 30.0\,\hat{\jmath} - 33.4\,\hat{k})$ lb, $\vec{P} = (50.0\,\hat{\imath} - 70.7\,\hat{\jmath} + 50.0\,\hat{k})$ lb, $\vec{R} = (85.2\,\hat{\imath} - 13.9\,\hat{\jmath} + 29.2\,\hat{k})$ lb.

2.48 $\vec{P} = (-1.33\,\hat{\imath} + 0.766\,\hat{\jmath} + 1.29\,\hat{k})$ kN, $\vec{Q} = (-2.67\,\hat{\imath} + 2.67\,\hat{\jmath} + 1.33\,\hat{k})$ kN, $\vec{F} = (2.12\,\hat{\imath} + 1.50\,\hat{\jmath} + 1.50\,\hat{k})$ kN, $\vec{R} = (-1.87\,\hat{\imath} + 4.93\,\hat{\jmath} + 4.12\,\hat{k})$ kN.

2.50 $\vec{F} = (12.5\,\hat{\imath} - 14.5\,\hat{\jmath} + 16.1\,\hat{k})$ N where $\theta_x = 60°, \theta_y = 125°, \theta_z = 50°$; $\vec{P} = (49.4\,\hat{\imath} + 53.0\,\hat{\jmath} + 19.4\,\hat{k})$ N where $\theta_x = 48.8°, \theta_y = 45°, \theta_z = 75°$; $\vec{R} = (61.9\,\hat{\imath} + 38.5\,\hat{\jmath} + 35.5\,\hat{k})$ N where $\theta_x = 40.3°, \theta_y = 61.6°, \theta_z = 64.0°$.

2.52 $r_{BA} = 4.16$ km.

2.54 **(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)** $\theta_x = 75.5°, \theta_y = 64.3°, \theta_z = 30°$.

2.56 $\theta_h = 33.7°, \theta_v = 59.0°$.

2.58 $\vec{F}_B = (-44.4\,\hat{\imath} + 77.8\,\hat{\jmath} - 44.4\,\hat{k})$ lb, $\vec{F}_E = (44.4\,\hat{\imath} - 77.8\,\hat{\jmath} + 44.4\,\hat{k})$ lb.

2.60 $(x_E, y_E, z_E) = (80, 60, 120)$ mm, $\vec{F}_{EG} = (-47.1\,\hat{\imath} + 52.9\,\hat{\jmath} + 70.6\,\hat{k})$ N.

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

2.64 **(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.

2.66 $d = 5.77$ cm , $\theta = 41.4°$.

2.68 $\alpha = 4.70°$, $\beta = 9.43°$, $a = 12.2$ in., $b = 12.0$ in..

2.70 $F_\parallel = -67.4$ N, $F_\perp = 73.9$ N, The bead slides toward C.

2.72 Answer given in problem statement.

2.74 $F = 1.42$ kip, $\vec{F} = (-0.640\,\hat{\imath} - 0.0522\,\hat{\jmath} + 1.27\,\hat{k})$ kip.

2.76 5.83 N.

2.78 $F_\parallel = 37.5$ lb , $F_\perp = 14.0$ lb.

2.80 $W = 45.0$ N.

2.82 $F_\parallel = -1.71$ N, $F_\perp = 60.0$ N, The bead slides toward A.

2.84 $v = (1.15)s$.

2.86 51.7 mm.

2.88 12.0 in.

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

2.92 **(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.

2.94 Essay-type answer.

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

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

2.100 $\vec{v}_n = (-2.92\,\hat{\imath} - 7.87\,\hat{\jmath} - 6.30\,\hat{k})$ 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.

2.102 6.57 mm.

2.104 **(a)** and **(b)** 23.4 N·m.

2.106 $-8.8\,\text{kN} \le P \le 4.6\,\text{kN}$.

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

2.110 $P_\perp = (-0.970)\,P$, $P_\parallel = (0.243)\,P$.

2.112 $P_\parallel = 7.66\,\text{kN}$, $P_\perp = 6.43\,\text{kN}$, $\vec{P}_\parallel = (-3.48\,\hat{\imath} - 3.48\,\hat{\jmath} - 5.87\,\hat{k})$ kN, $\vec{P}_\perp = (3.48\,\hat{\imath} + 3.48\,\hat{\jmath} - 4.13\,\hat{k})$ kN.

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

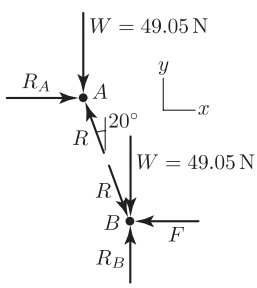
2.116 Answers given in problem statement.

Chapter 3

3.2 $R_C = R_D = 31.8$ lb.

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

3.6 **(a)** $F = 17.9$ N, $R_A = 17.9$ N, $R_B = 98.1$ N, $R = 52.2$ N **(b)** Block A may move with constant velocity but it will not accelerate. **(c)** Block B will accelerate to the right.



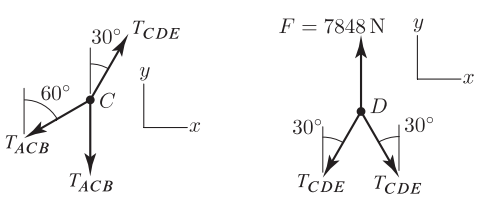
3.8 $T_{AB} = 5.13$ kN, $T_{AC} = 0.340$ kN.

3.10 $F_{AB} = 1580$ lb, $T_{AC} = -1500$ lb.

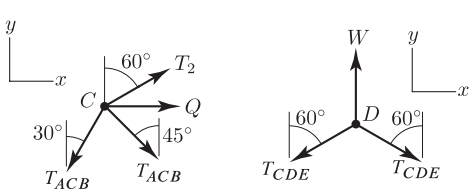
3.12 **(a)** $T_{AB} = 175$ N; **(b)** $T_{CD} = T_{CE} = 109$ N; **(c)** Essay-type answer.

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

3.16 $T_{ACB} = 2620$ N, $T_{CDE} = 4530$ N.



3.18 $m = 547$ kg.



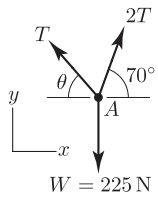
3.20 $T_{CD} = 8420$ N, $T_{BA} = 6840$ N, $T_{CB} = 7890$ N, $W = 2110$ N.

3.22 **(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.

3.24 $W = 218$ lb.

3.26 $T_{BH} = 540$ lb, $T_{HE} = 540$ lb, $T_{BC} = 717$ lb, $T_{EF} = 586$ lb, $W_A = 322$ lb, $W_G = 369$ lb, $W_D = 108$ lb.

3.28 $\theta = 46.8°$, $T = 86.2\,\text{N}$.



3.30 $W_1 = 32.6\,\text{N}$, $W_2 = 11.3\,\text{N}$.

3.32 $\alpha = -30°$; *intermediate answer:* $F_{BD} = \frac{(5\,\text{lb})(\cos 30° + \sin 30°)}{\cos 30° \cos\alpha - \sin 30° \sin\alpha}$.

3.34 $T_{AC} = 3460\,\text{lb}$, $T_{AE} = 6000\,\text{lb}$, $T_{AG} = 4240\,\text{lb}$, $\delta = 6.00\,\text{in}$.

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

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

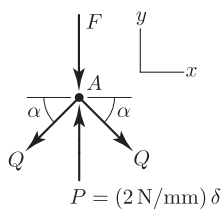
3.40 $k = 167\,\text{lb/in.}$, $L_0 = 21.0\,\text{in}$.

3.42 $F_1 = 128\,\text{lb}$, $F_2 = 335\,\text{lb}$, $F_3 = 128\,\text{lb}$.

3.44 $\delta = 3.42\,\text{mm}$.

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

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



3.50 $m_D = 91.7\,\text{kg}$.

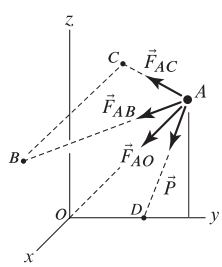
3.52 $W = 500\,\text{N}$.

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

3.56 $P = 800\,\text{lb}$.

3.58 $P = 800\,\text{lb}$.

3.60 $P = 1450\,\text{lb}$.



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

3.64 $F_{AB} = F_{AC} = 780\,\text{lb}$, $R = 800\,\text{lb}$.

3.66 $W = 400\,\text{N}$, $R_1 = 300\,\text{N}$, $R_2 = 13.7\,\text{N}$, $\vec{R}_1 = (-27.2\,\hat{\imath} + 218\,\hat{\jmath} + 204\,\hat{k})\,\text{N}$, $\vec{R}_2 = (-12.8\,\hat{\imath} + 2.27\,\hat{\jmath} - 4.13\,\hat{k})\,\text{N}$.

3.68 $P = 107\,\text{N}$, $\vec{R} = (32.0\,\hat{\imath} + 42.6\,\hat{\jmath} - 107\,\hat{k})\text{N}$.

3.70 $F_{ED} = 280\,\text{lb}$, $F_{EF} = 360\,\text{lb}$, $F_{FB} = 210\,\text{lb}$, $F_{EA} = 380\,\text{lb}$, $F_{FC} = 210\,\text{lb}$, 60 lb must be added to traffic light E.

3.72 Essay-type answer.

3.74 $T_{AE} = 44.6\,\text{lb}$, $T_{AD} = 69.6\,\text{lb}$, $T_{DF} = 192\,\text{lb}$, $T_{DG} = 274\,\text{lb}$, $T_{ABCD} = 100\,\text{lb}$.

3.76 $\theta = 19.1°$, $T_{AB} = 153\,\text{N}$.

3.78 $F = 90.1\,\text{N}$.

3.80 $\delta_1 = 10.0\,\text{mm}$, $\delta_2 = 10.0\,\text{mm}$.

3.82 $T_{AB} = 9.33\,\text{kN}$, $T_{AC} = 9.33\,\text{kN}$, $T_{AD} = 16.0\,\text{kN}$, $T_{AE} = 8.00\,\text{kN}$.

3.84 $T_{AB} = 8.40\,\text{kN}$, $T_{AD} = 8.00\,\text{kN}$, $T_{AC} = 9.33\,\text{kN}$, $T_{AE} = 8.00\,\text{kN}$.

3.86 The bead slides toward B.

3.88 $T_{AC} = 1650\,\text{lb}$, $T_{BC} = 106\,\text{lb}$, $T_{CD} = 2330\,\text{lb}$, $F_{CE} = -1400\,\text{lb}$, $F_{CF} = -1400\,\text{lb}$, $P = 106\,\text{lb}$.

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

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

4.6 **(a)** $F = 20.1\,\text{lb}$; **(b)** $F = 56.1\,\text{lb}$; **(c)** $k = 13.0\,\text{lb/in.}$

4.8 $F = 640\,\text{lb}$, $\alpha = 140°$.

4.10 **(a)** $M_A = 30.0\,\text{kN}\cdot\text{m}$; **(b)** $M_A = 35.0\,\text{kN}\cdot\text{m}$; **(c)** $M_A = 38.0\,\text{kN}\cdot\text{m}$.

4.12 **(a)** $Q = 10.0\,\text{kN}$; **(b)** $W = 5.00\,\text{kN}$, $\alpha = 53.1°$.

4.14 $F = -100\,\text{N}$.

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

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

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

4.22 $F = 1.75\,\text{kN}$.

4.24 **(a)** $F = 240\,\text{N}$, **(b)** $\vec{M}_O = -912\,\hat{\imath}\,\text{N}\cdot\text{m}$; **(c)** Essay-type answer.

4.26 **(a)** $M_{AB} = 1900\,\text{N}\cdot\text{mm}$, $\vec{F} = (3.85\,\hat{\imath} + 9.23\,\hat{k})\,\text{N}$; **(b)** $M_{AB} = 472\,\text{N}\cdot\text{mm}$; **(c)** $M_{AB} = 0$.

4.28 $F = 92.6\,\text{lb}$.

4.30 $F = 115\,\text{N}$. Twisting occurs at both fittings on pipe OA.

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

4.34 $M_{OB} = 12.5\,\text{N}\cdot\text{m}$.

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

4.38 $\vec{F} = (35.8\,\hat{\jmath} + 17.9\,\hat{k})\,\text{lb}$, $M_{GH} = 537\,\text{in.}\cdot\text{lb}$.

4.40 $\vec{Q} = (6\,\hat{\imath} + 6\,\hat{\jmath} + 3\,\hat{k})\,\text{lb}$, $M_{BC} = -290\,\text{in.}\cdot\text{lb}$.

4.42 $M_a = -17{,}400\,\text{ft}\cdot\text{lb}$, $\alpha = 90°$.

4.44 $M = 144\,\text{in.}\cdot\text{lb}$.

4.46 **(a)** $Q = 120\,\text{N}$; **(b)** The answer does not change.

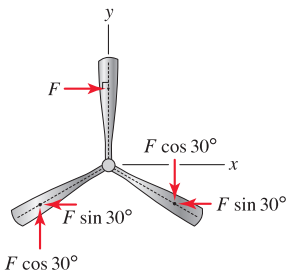
4.48 **(a)** $M = 96.6\,\text{N}\cdot\text{mm}$; **(b)** $M = 96.6\,\text{N}\cdot\text{mm}$.

4.50 $\vec{M} = (200\,\hat{\imath} - 600\,\hat{k})\,\text{N}\cdot\text{m}$.

4.52 $d = 1.92\,\text{m}$.

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

4.56 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.



4.58 $\vec{F}_A = (42\,\text{lb})(-0.976\,\hat{\imath} + 0.484\,\hat{\jmath} - 0.179\,\hat{k})$, $\vec{F}_B = -\vec{F}_A = (42\,\text{lb})(0.976\,\hat{\imath} - 0.484\,\hat{\jmath} + 0.179\,\hat{k})$; *Additional result:* the moment of the couple about line a is $M_a = 921$ in.·lb.

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

4.62 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.

4.64 $F_{Rx} = -1490$ lb, $F_{Ry} = -102$ lb, $M_R - 5110$ in.·lb.

4.66 $F_{Rx} = -0.500$ kN, $F_{Ry} = -3.87$ kN, 2.58 m to the right of the bearing at C.

4.68 **(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, $(x, y) = (-3.86\,\text{mm}, -6.67\,\text{mm})$.

4.70 **(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.

4.72 **(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.

4.74 $\vec{F}_R = -2F\,\hat{k}$, $\vec{M}_R = 3Pr\,\hat{k}$, $(x, y) = (0, r)$.

4.76 $\vec{F}_R = (2.00\,\hat{\imath} + 3.00\,\hat{\jmath} - 4.00\,\hat{k})$ N, $\vec{M}_{RA} = (9.00\,\hat{\imath} + 8.00\,\hat{\jmath} - 4.00\,\hat{k})$ N·m.

4.78 $\vec{F}_R = F(-\hat{\jmath} + \hat{k})$, $\vec{M}_R = Fa\frac{1}{2}(-\hat{\jmath} + \hat{k})$, $(x, y) = (\frac{1}{2}a, b)$.

4.80 $\vec{M}_R = (150\,\hat{\imath} + 104\,\hat{\jmath} - 200\,\hat{k})$ N·m.

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

4.84 $F = 300$ lb.

4.86 $P = -10$ lb, $Q = -5$ lb, $R = 0$, $S = -20$ lb, $M_D = -10$ in.·lb.

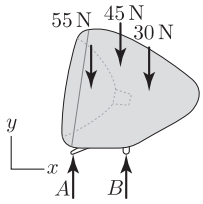
4.88 **(a)** $F_{Rx} = -0.880$ lb, $F_{Ry} = -0.660$ lb, $M_O = 0.552$ in.·lb; **(b)** $F_{Rx} = -0.880$ lb, $F_{Ry} = -0.660$ lb, $y = 0.627$ in.

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

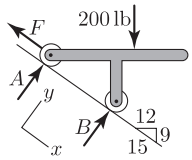
4.92 $\vec{F}_R = (-30.0\,\hat{\imath} - 120\,\hat{\jmath} - 22.5\,\hat{k})$ lb, $\vec{M}_{RO} = (-990\,\hat{\imath} + 60.0\,\hat{\jmath} + 1180\,\hat{k})$ in.·lb.

Chapter 5

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



5.4 $F = 120$ lb, $B = 213$ lb, $A = -53.5$ lb.



5.6 $B = 42.9\,\text{N}$ (force supported by *one* link), $A_x = 68.6\,\text{N}$, $A_y = -51.4\,\text{N}$.

5.8 $d = 3.10\,\text{ft}$.

5.10 **(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)** $A_x = 0$, $A_y = F + P$, $M_A = \frac{1}{3}L(F + 2P)$.

5.12 $A_y = 1.88\,\text{kN}$, $E_y = 2.12\,\text{kN}$, $E_x = -2.00\,\text{kN}$.

5.14 $A_x = 0$, $A_y = 3.00\,\text{kip}$, $P_y = 1.00\,\text{kip}$.

5.16 $C_y = 11{,}300\,\text{lb}$, $D_y = 6170\,\text{lb}$.

5.18 $A_x = 0$, $B_y = P$, $M_A = Pa$.

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

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

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

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

5.28 Essay-type answer.

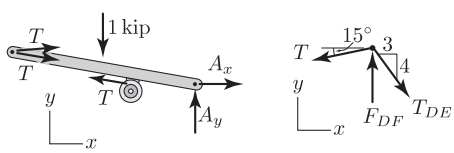
5.30 $F_x = 9.08\,\text{lb}$, $F_y = -4.82\,\text{lb}$, $E_y = 17.0\,\text{lb}$.

5.32 $G = 4.66\,\text{N}$, $N = 17.4\,\text{N}$, $\theta = 17.0°$.

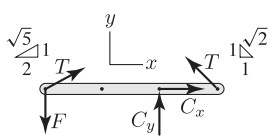
5.34 $A_x = 0$, $A_y = 200\,\text{lb}$, $T = 600\,\text{lb}$.

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

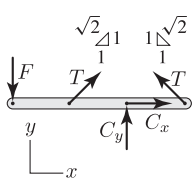
5.38 $T = 1.66\,\text{kip}$ (tension in cable BCD), $A_x = -1.66\,\text{kip}$, $A_y = 0.55\,\text{kip}$ $T_{DE} = 2.76\,\text{kip}$, $F_{DF} = 2.36\,\text{kip}$.



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



5.42 **(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.



5.44 $F = 13.6\,\text{lb}$.

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

5.48 Essay-type answer

5.50 $A_x = 0$, $A_y = F\Big[1 - \dfrac{kL^2}{2(k_t + kL^2)}\Big]$, $C_y = \dfrac{FkL^2}{2(k_t + kL^2)}$, $M_A = \dfrac{FL}{2}\Big[1 - \dfrac{kL^2}{k_t + kL^2}\Big]$.

5.52 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.

5.54 $D = 0.314\,\text{N}$, $L = 1.34\,\text{N}$.

5.56 $\delta = 2.40\,\text{mm}$, $\theta = 1.49°$.

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

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

5.62 $ABDE$ is a multiforce member and BC is a 2-force member.

5.64 3-force member.

5.66 3-force member.

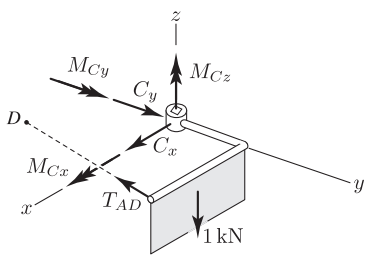
5.68 $ABCD$ is a multiforce member and DE is a 2-force member.

5.70 Multiforce member.

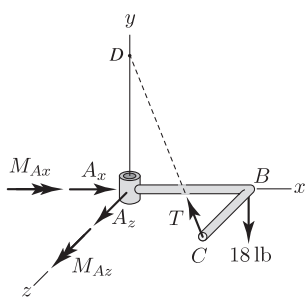
5.72 3-force member.

5.74 $F_{AB} = 318\,\text{kN}$ 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.

5.76 $C_x = 0.333\,\text{kN}$, $C_y = 0.667\,\text{kN}$, $T_{AD} = 1.25\,\text{kN}$, $M_{Cx} = 0$, $M_{Cy} = 2.00\,\text{kN·m}$, $M_{Cz} = 3.33\,\text{kN·m}$.

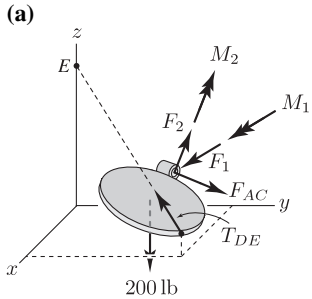


5.78 **(a)** Partial fixity and statically determinate; **(b)** $T = 27\,\text{lb}$, $A_x = 18.0\,\text{lb}$, $A_y = 9.00\,\text{lb}$, $M_{Ax} = 54.0\,\text{in.·lb}$, $M_{Az} = 0$.

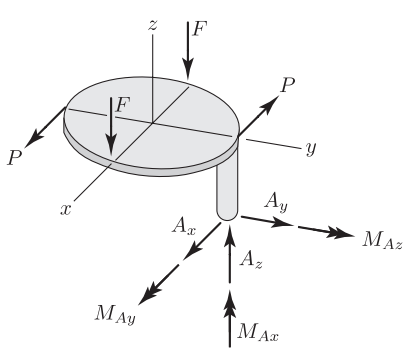


5.80 $T_{AD} = 50.75\,\text{kN}$.

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

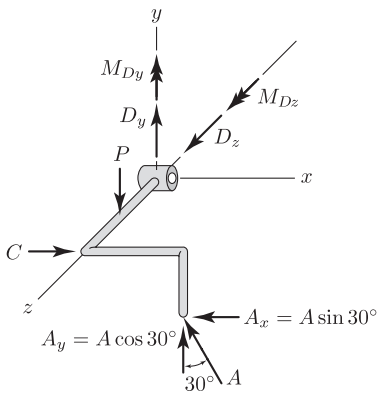


5.84 $A_x = 0$, $A_y = 0$, $A_z = 2F$, $M_{Ax} = -2Fr$, $M_{Ay} = 0$, $M_{Az} = -2Pr$.



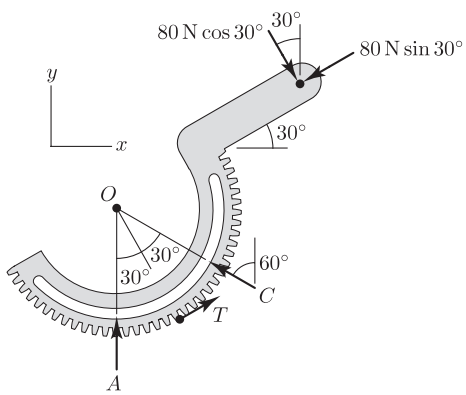
5.86 $F = 3.21\,\text{kN}$, $C_x = -3.00\,\text{kN}$, $C_y = 2.07\,\text{kN}$, $C_z = -0.429\,\text{kN}$, $M_{Cx} = 0.343\,\text{kN·m}$, $M_{Cy} = -0.600\,\text{kN·m}$.

5.88 $A = 5.77\,\text{kN}$, $C = 2.89\,\text{kN}$, $D_y = 5.00\,\text{kN}$, $D_z = 0$, $M_{Dy} = 0$, $M_{Dz} = -9.23\,\text{kN·m}$.



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

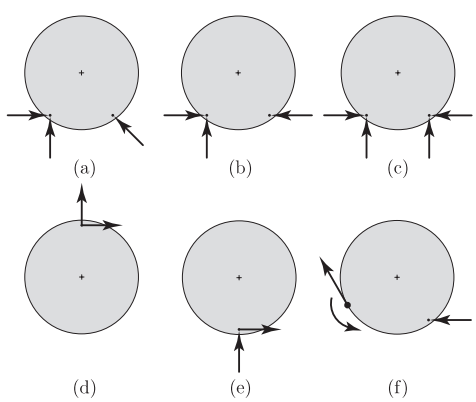
5.92 $T = 163\,\text{N}$, $C = 163\,\text{N}$, $A = -83.2\,\text{N}$.



5.94 $A_x = 7.00\,\text{N}$, $A_y = 26.1\,\text{N}$, $M_A = -276\,\text{N·cm}$.

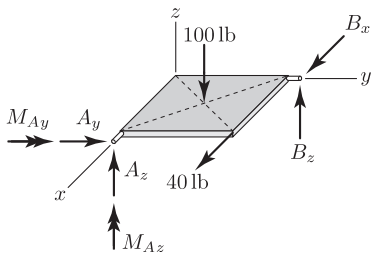
5.96 **(a)** $F = 3.29\,\text{N}$; **(b)** $F = 11.5\,\text{N}$; **(c)** $F = 20.1\,\text{N}$.

5.98 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.



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

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



Chapter 6

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

6.4 $P = 3200\,\text{lb}$.

6.6 $P = 8000\,\text{lb}$.

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

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

6.12 $P = 10.0\,\text{kN}$.

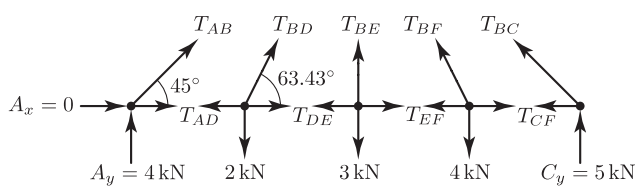
6.14 $P = 6.66\,\text{kN}$.

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



6.24 **(a)** FG, DG; **(b)** $T_{FG} = 0$, $T_{DG} = 0$, $T_{AC} = -12.0\,\text{kN}$, $T_{AB} = 10.4\,\text{kN}$, $T_{CB} = 4.00\,\text{kN}$, $T_{BD} = 10.4\,\text{kN}$, $T_{GH} = -8.00\,\text{kN}$, $T_{FH} = 6.93\,\text{kN}$, $T_{EG} = -8.00\,\text{kN}$, $T_{CE} = -8.00\,\text{kN}$, $T_{DE} = 8.00\,\text{kN}$, $T_{CD} = -16.0\,\text{kN}$, $T_{DF} = 6.93\,\text{kN}$.

6.26 **(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)** $T_{DI} = 0$, $T_{EJ} = 0$, $T_{DE} = 0$, $T_{CD} = 0$, $T_{CJ} = -14.4\,\text{kip}$, $T_{IJ} = 9.00\,\text{kip}$, $T_{CI} = 10.0\,\text{kip}$, $T_{HI} = 3.00\,\text{kip}$.

6.28 $T_{BD} = -5.77P$, $T_{CD} = 5.77P$, $T_{CE} = -8.66P$

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

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

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

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

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

6.40 **(a)** For truss system (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 system (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.

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

6.44 Answers to be provided.

6.46 Answers to be provided.

6.48 Answers to be provided.

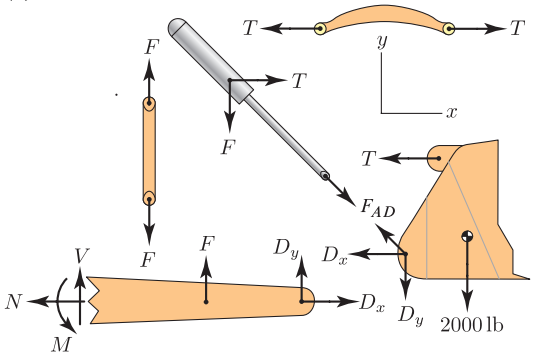
6.50 FBDs to be provided.

6.52 Essay-type answer.

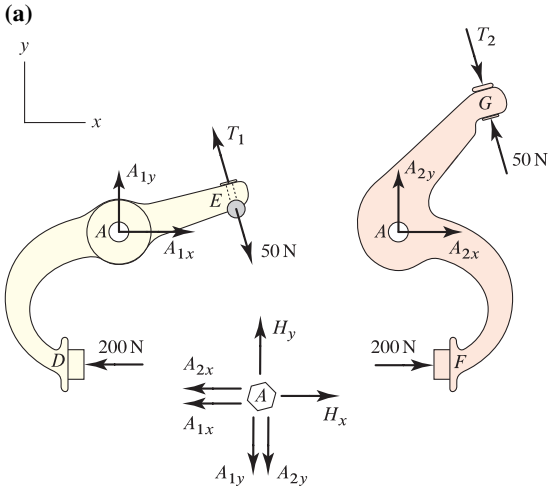
6.54 Horizontal force applied by the operator is $Q = 20.8\,\text{lb}$, $T_{AE} = -6.67\,\text{lb}$, $B_x = -5.77\,\text{lb}$, $B_y = 13.3\,\text{lb}$, $C_x = -15.0\,\text{lb}$, $C_y = 13.3\,\text{lb}$.

6.56 Horizontal force applied by the operator is $Q = -47.7\,\text{N}$, $F_{BE} = 63.0\,\text{N}$, $A_x = 55.7\,\text{N}$, $A_y = 10.7\,\text{N}$, $C_x = -103\,\text{N}$, $C_y = 10.7\,\text{N}$.

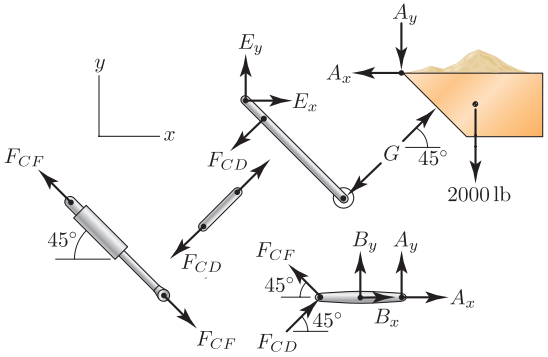
6.58 **(b)** $F_{AD} = -3390\,\text{lb}$;
(a)



6.60 **(b)** $T_1 = 283\,\text{N}$, $T_2 = 283\,\text{N}$; **(c)** from DE: $A_x = 260\,\text{N}$, $A_y = -225\,\text{N}$, from FG: $A_x = -260\,\text{N}$, $A_y = 225\,\text{N}$;
(a)

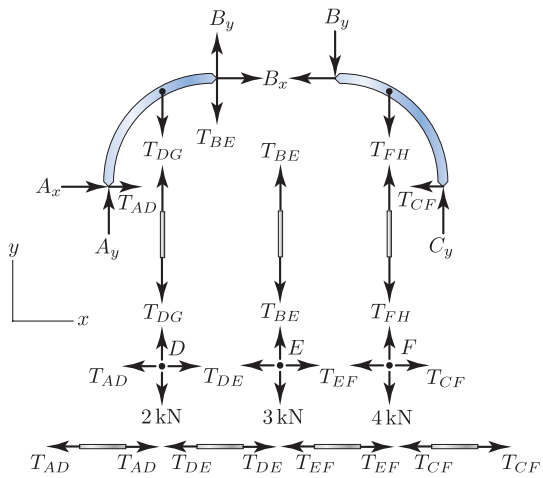


6.62 **(b)** $F_{CF} = 27{,}200\,\text{lb}$;
(a)



6.64 $F_{FH} = 22.5\,\text{N}$, $F_{BF} = -70.8\,\text{N}$.

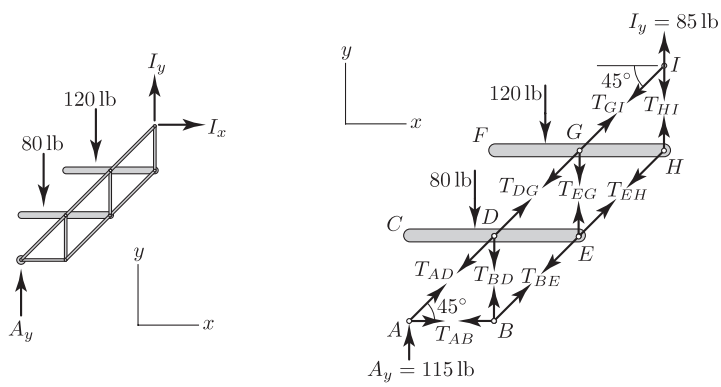
6.66 **(a)** The structure is not a truss, essay-type answer; **(b)** $T_{DG} = 2.00\,\text{kN}$, $T_{BE} = 3.00\,\text{kN}$, $T_{FH} = 4.00\,\text{kN}$, $T_{AD} = 3.00\,\text{kN}$, $T_{DE} = 3.00\,\text{kN}$, $T_{EF} = 3.00\,\text{kN}$, $T_{CF} = 3.00\,\text{kN}$, $B_x = -3.00\,\text{kN}$, $B_y = 1.00\,\text{kN}$.



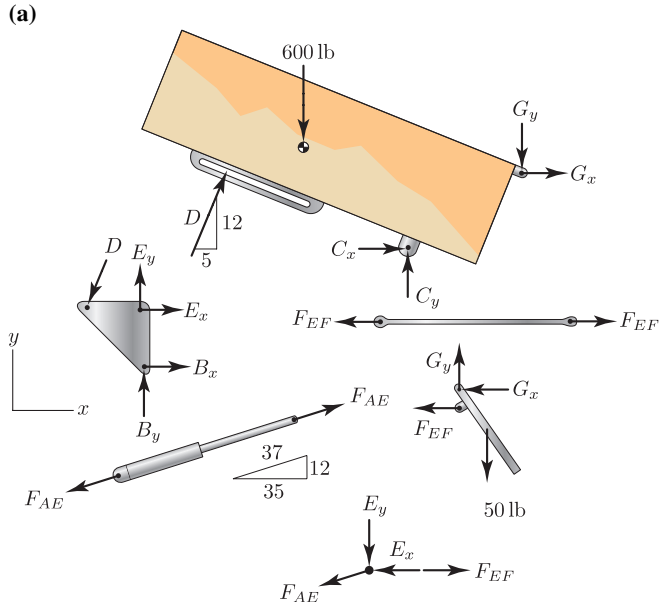
6.68 **(a)** Statically indeterminate; **(b)** QH and IQ, **(c)** $F_{DG} = \sqrt{2}\,\text{kN}$.

6.70 $T_{BP} = 813\,\text{lb}$, $T_{BO} = 813\,\text{lb}$, $T_{CD} = 100\,\text{lb}$.

6.72 $T_{AD} = -163\,\text{lb}$, $T_{AB} = 115\,\text{lb}$, $T_{BE} = 163\,\text{lb}$, $T_{BD} = -115\,\text{lb}$, $T_{GI} = 0$, $T_{HI} = 85.0\,\text{lb}$, $T_{EH} = 184\,\text{lb}$, $T_{DG} = -184\,\text{lb}$, $T_{EG} = -35.0\,\text{lb}$.



6.74 **(b)** $F_{AE} = -525\,\text{lb}$;
(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 $(\bar{x}, \bar{y}) = (\frac{6}{5}, \frac{3}{2})$ mm.

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

7.16 $(\bar{x}, \bar{y}) = (48.0, 16.0)$ in.

7.18 Answer given in problem statement.

7.20 $c_1 = b/\sqrt{a}$, $c_2 = b/a^3$, $(\bar{x}, \bar{y}) = (\frac{12}{25}a, \frac{3}{7}b)$.

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

(c) $(\bar{x}, \bar{y}) = (0.609, 0.366)$ in.

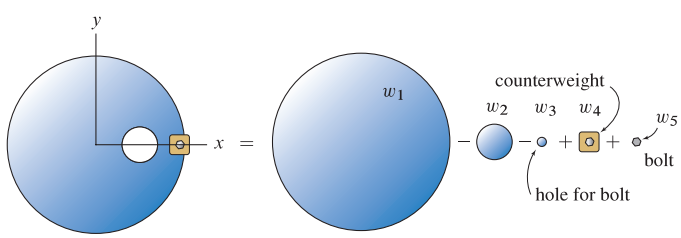
7.24 **(a)** $\bar{x} = \dfrac{\int_{-r}^{r} x\sqrt{1+\left(\frac{-x}{\sqrt{r^2-x^2}}\right)^2}\,dx}{\int_{-r}^{r} \sqrt{1+\left(\frac{-x}{\sqrt{r^2-x^2}}\right)^2}\,dx}$, $\bar{y} = \dfrac{\int_{-r}^{r} \sqrt{r^2-x^2}\sqrt{1+\left(\frac{-x}{\sqrt{r^2-x^2}}\right)^2}\,dx}{\int_{-r}^{r} \sqrt{1+\left(\frac{-x}{\sqrt{r^2-x^2}}\right)^2}\,dx}$;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

7.26 $\bar{x} = \frac{11}{28}R$.

7.28 $(\bar{x}, \bar{y}, \bar{z}) = (133, 0, 0)$ in.

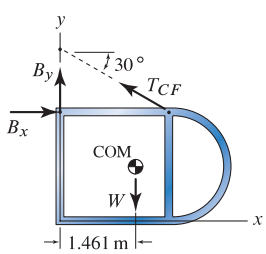
7.30 $(\bar{x}, \bar{y}, \bar{z}) = (2.98, 0, 0)$ in.

7.32 $m_c = 680$ g.



7.34 $(\bar{x}, \bar{y}, \bar{z}) = (1.07, 0, 0.876)$ in.

7.36 $(\bar{x}, \bar{y}) = (1.46, 1.00)$ m, mass of frame $m = 44.6$ kg, $T = 639$ N, $B_x = 553$ N, $B_y = 118$ N.



7.38 **(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)** $\bar{x} = \frac{25}{56}r$.

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

7.42 **(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)** $\bar{x} = \frac{75}{124}L$.

7.44 **(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)** $\bar{x} = \frac{11}{10}$ cm.

7.46 $V = 283\,\text{mm}^3$, $A = 226\,\text{mm}^2$.

7.48 $V = 1.78\times10^3\,\text{mm}^3$, $A = 1.98\times10^3\,\text{mm}^2$.

7.50 $V = 8\pi h^3$, $A = \pi h^2(11 + 8\sqrt{2})$.

7.52 $V = 19.8\,\text{in.}^3$, $W_c = 0.118\,\text{lb}$.

7.54 **(a)** $V = 327\,\text{mm}^3$; **(b)** $A_{\text{outside}} = 34.6\times10^3\,\text{mm}^2$; **(c)** $A_{\text{inside}} = 12.2\times10^3\,\text{mm}^2$.

7.56 $V = \frac{7\pi}{12}R^3$, $A = \frac{\pi}{4}(11 + \sqrt{5})R^2$.

7.58 **(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 $0 \le x \le 18\,\text{in.}$, $w = 5.56\,\text{lb/in.} - (0.1029\,\text{lb/in.}^2)x$ for $18\,\text{in.} \le x \le 36\,\text{in.}$

7.60 $A_x = 0$, $A_y = 33.3\,\text{lb}$, $B_y = 66.7\,\text{lb}$.

7.62 $A_x = 0$, $A_y = 49.1\,\text{kN}$, $M_A = 98.1\,\text{kN·m}$.

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

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

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

7.72 $A_x = 0$, $A_y = -4.00\,\text{kN}$, $B_y = 16.0\,\text{kN}$.

7.74 $A_x = 0$, $A_y = -40.0\,\text{kip}$, $B_y = 40.0\,\text{kip}$.

7.76 $A_x = 0$, $A_y = 6.08\,\text{kip}$, $B_y = 4.92\,\text{kip}$.

7.78 $C_x = 0$, $C_y = 12.0\,\text{kN}$, $M_C = -24\,\text{kN·m}$.

7.80 $A_x = 0$, $A_y = -80\,\text{kip}$, $C_y = 80\,\text{kip}$.

7.82 $A_x = 0$, $A_y = w_1 a + w_2(L - a)$, $M_A = \frac{1}{2}w_1 a^2 + \frac{1}{2}w_2(L^2 - a^2)$.

7.84 $a = 0.524\,\text{kN/m}$, $b = 1.21\,\text{kN/m}^2$, $c = -0.0556\,\text{kN/m}^3$, $F = 23.0\,\text{kN}$, $\bar{x} = 4.05\,\text{m}$.

7.86 $A_x = 0$, $A_y = 0$, $A_z = W$, $M_{Ax} = -WR(1 - \frac{2}{\pi})$, $M_{Ay} = -\frac{2}{\pi}WR$, $M_{Az} = 0$.

7.88 $T = \gamma d^3$.

7.90 $T = 39.0\,\text{lb}$.

7.92 $\theta_0 = 0.235\,\text{rad} = 13.5°$.

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

7.96 $T_B = 414\,\text{N}$, $T_C = 287\,\text{N}$, $T_D = 684\,\text{N}$.

7.98 $F_{EG} = 381\,\text{lb}$.

7.100 $(\bar{x}, \bar{y}) = (0, 20.2)\,\text{mm}$

7.102 $(\bar{x}, \bar{y}) = (\frac{56}{25}, 1)\,\text{m}$

7.104 $(\bar{x}, \bar{y}, \bar{z}) = (34.7, 0, 0)\,\text{mm}$.

7.106 **(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)** $(\bar{x}, \bar{y}, \bar{z}) = (3.20, 0, 0)\,\text{mm}$.

7.108 $\bar{x} = \frac{4}{3}\,\text{m}$.

7.110 $\bar{x} = \frac{\int_0^{1\,\text{cm}} x\pi(1+x^2)^2\,dx}{\int_0^{1\,\text{cm}} \pi(1+x^2)^2\,dx}$, **(b)** $\bar{x} = \frac{5}{8}\,\text{cm}$.

7.112 **(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)** $(\bar{x}, \bar{y}) = (0.801, 1.48)\,\text{km}$.

7.114 $V = \frac{4\pi}{3}r^3$, $A = 4\pi r^2$.

7.116 $V = 4360\,\text{cm}^3$, $A = 867\,\text{cm}^2$.

7.118 $A_x = 0$, $A_y = 1700\,\text{lb}$, $B_y = 1300\,\text{lb}$.

7.120 $B_y = 640\,\text{lb}$, $C_x = 0$, $C_y = 1460\,\text{lb}$ where pin C is located 6 ft from the left-hand end of the beam.

7.122 $A_x = 0$, $A_y = 2.17\,\text{kN}$, $C_y = 3.83\,\text{kN}$ where roller C is located 2 m from the right-hand end of the beam.

7.124 $A_x = -46.8\,\text{lb}$, $A_y = 281\,\text{lb}$, $C_x = 187\,\text{lb}$.

7.126 $d = -12.5\,\text{mm}$.

Chapter 8

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

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

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

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

8.10 $N_D = 0$, $V_D = 100\,\text{lb}$, $M_D = 0$, $N_E = 0$, $V_E = 100\,\text{lb}$, $M_E = -150\,\text{in.}\cdot\text{lb}$, $N_F = -70.7\,\text{lb}$, $V_F = 70.7\,\text{lb}$, $M_F = -256\,\text{in.}\cdot\text{lb}$.

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

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

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

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

8.20 $N_L = 462\,\text{lb}$, $V_L = -653\,\text{lb}$, $M_L = 1600\,\text{ft}\cdot\text{lb}$, $N_M = 0$, $V_M = -800\,\text{lb}$, $M_M = 0$.

8.22 Essay-type answer.

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

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

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

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 $V = (-8.00\,\text{kN/m})\,x$, $M = (-4.00\,\text{kN/m})\,x^2$.

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 $V = 3.00\,\text{N}$, $M = -8.00\,\text{N}\cdot\text{mm} + (3.00\,\text{N})\,x$ 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 $4\,\text{mm} \le x \le 6\,\text{mm}$.

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

8.48 Essay-type answer.

8.50 $V = -100\,\text{lb/ft}(6.00\,\text{ft} - x) + 1000\,\text{lb}$, $M = -50\,\text{lb/ft}[(12.0\,\text{ft})x - x^2] + (1000\,\text{lb})\,x$ for $0 \le x \le 6\,\text{ft}$; $V = -100\,\text{lb/ft}(6.00\,\text{ft} - x) - 1000\,\text{lb}$, $M = -50\,\text{lb/ft}[(12.0\,\text{ft})x - x^2] + (1000\,\text{lb})(12\,\text{ft} - x)$ for $6\,\text{ft} \le x \le 12\,\text{ft}$.

8.52 $V = 1000\,\text{N}$, $M = (1000\,\text{N})\,x$ for $0 \le x \le 1\,\text{m}$; $V = 100\,\text{N}$, $M = (100\,\text{N})(9.00\,\text{m} + x)$ for $1\,\text{m} \le x \le 2\,\text{m}$; $V = -1100\,\text{N}$, $M = (1100\,\text{N})(3.00\,\text{m} - x)$ for $2\,\text{m} \le x \le 3\,\text{m}$.

8.54 $V = (0.202\,\text{kip/in.})\,x$, $M = (0.101\,\text{kip/in.})x^2$ for $0 \le x \le 20\,\text{in.}$; $V = -10.0\,\text{kip} + (0.202\,\text{kip/in.})\,x$, $M = 200\,\text{in.}\cdot\text{lb} - (10.0\,\text{kip})\,x + (0.101\,\text{kip/in.})x^2$ 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 $79\,\text{in.} \le x \le 99\,\text{in.}$

8.56 $V = (-8.00\,\text{kN/m})\,x$, $M = (-4.00\,\text{kN/m})\,x^2$.

8.58 $V = 60\,\text{kN} - (8.00\,\text{kN/m})\,x - (\frac{1}{3}\,\text{kN/m}^2)\,x^2$, $M = -192\,\text{kN}\cdot\text{m} + (60.0\,\text{kN})\,x - (4\,\text{kN/m})\,x^2 - (\frac{1}{9}\,\text{kN/m}^2)\,x^3$.

8.60 $V = 4000\,\text{lb} - (15.0\,\text{lb/ft})[(40.0\,\text{ft})x - x^2]$, $M = (4000\,\text{lb})\,x - (5.00\,\text{lb/ft}^2)[(60\,\text{ft})x^2 - x^3]$, $M_{\max} = 15{,}400\,\text{ft}\cdot\text{lb}$ at $x = 8.45\,\text{ft}$.

8.62 $V = \frac{1}{6}w_0L - w_0(x - \frac{1}{L}x^2)$, $M = w_0(\frac{L}{6}x - \frac{1}{2}x^2 + \frac{1}{3L}x^3)$, $M_{\max} = (0.0160)w_0L^2$ at $x = (0.211)L$ and $M_{\max} = (-0.0160)w_0L^2$ at $x = (0.789)L$.

8.64 $V = 2P$, $M = -\frac{3}{2}PL + 2Px$ for $0 \le x \le \frac{L}{2}$; $V = P$, $M = -\frac{1}{2}PL + P(x - \frac{1}{2}L)$ for $\frac{L}{2} \le x \le L$.

8.66 $V = (-25.0\,\text{lb/ft}^2)\,x^2$, $M = (-\frac{25}{3}\,\text{lb/ft}^2)\,x^3$ for $0 \le x \le 4\,\text{ft}$; $V = 1800\,\text{lb} - (25.0\,\text{lb/ft}^2)\,x^2$, $M = -7200\,\text{ft}\cdot\text{lb} + (1800\,\text{lb})\,x - (\frac{25}{3}\,\text{lb/ft}^2)\,x^3$ for $4\,\text{ft} \le x \le 12\,\text{ft}$.

8.68 $V = (-1.00\,\text{kN/m})\,x$, $M = (-0.500\,\text{kN/m})\,x^2$ for $0 \le x \le 1.3\,\text{m}$; $V = -6.86\,\text{kN} - (1.00\,\text{kN/m})(x - 1.30\,\text{m})$, $M = 7.22\,\text{kN}\cdot\text{m} - (5.56\,\text{kN})\,x - (0.500\,\text{kN/m})\,x^2$ for $1.3\,\text{m} \le x \le 4\,\text{m}$; $V = -14.0\,\text{kN} - (1.00\,\text{kN/m})(x - 4.00\,\text{m})$, $M = 25.0\,\text{kN}\cdot\text{m} - (10.0\,\text{kN})\,x - (0.500\,\text{kN/m})\,x^2$ for $4\,\text{m} \le x \le 5.5\,\text{m}$.

8.70 $V_{\max} = 4P$ at $x = 0$, $M_{\max} = -10Pd$ at $x = 0$.

8.72 $V_{\max} = -45.0\,\text{N}$ just to the left of $x = 30\,\text{mm}$, $M_{\max} = -1130\,\text{N}\cdot\text{mm}$ at $x = 30\,\text{mm}$.

8.74 $V_{\max} = 10.0\,\text{lb}$ just to the right of $x = 17\,\text{in.}$, $M_{\max} = -16.0\,\text{in.}\cdot\text{lb}$ at $x = 4\,\text{in.}$

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

8.78 $N_F = -6.19\,\text{kip}$, $V_F = 0.940\,\text{kip}$, $M_F = 0$, $N_G = -6.19\,\text{kip}$, $V_G = 0.940\,\text{kip}$, $M_G = 4.00\,\text{kip}\cdot\text{ft}$.

8.80 $N_E = -833\,\text{N}$, $V_E = 833\,\text{N}$, $M_E = 0$, $N_F = -1180\,\text{N}$, $V_F = 0$, $M_F = -69.0\,\text{N}\cdot\text{m}$, $N_G = 833\,\text{N}$, $V_G = -833\,\text{N}$, $M_G = 0$.

8.82 $V = 12.0\,\text{kN} - (0.750\,\text{kN/m}^2)\,x^2$, $M = (12.0\,\text{kN})\,x - (0.250\,\text{kN/m}^2)\,x^3$ for $0 \le x \le 4\,\text{m}$; $V = 36.0\,\text{kN} - (12.0\,\text{kN/m})\,x + (0.750\,\text{kN/m}^2)\,x^2$, $M = -32.0\,\text{kN}\cdot\text{m} + (36.0\,\text{kN})\,x - (6.00\,\text{kN/m})\,x^2 + (0.250\,\text{kN/m}^2)\,x^3$ for $4\,\text{m} \le x \le 8\,\text{m}$.

8.84 $V = 12.0\,\text{kN} - (0.750\,\text{kN/m}^2)\,x^2$, $M = (12.0\,\text{kN})\,x - (0.250\,\text{kN/m}^2)\,x^3$ for $0 \le x \le 4\,\text{m}$; $V = 36.0\,\text{kN} - (12.0\,\text{kN/m})\,x + (0.750\,\text{kN/m}^2)\,x^2$, $M = -32.0\,\text{kN}\cdot\text{m} + (36.0\,\text{kN})\,x - (6.00\,\text{kN/m})\,x^2 + (0.250\,\text{kN/m}^2)\,x^3$ for $4\,\text{m} \le x \le 8\,\text{m}$.

8.86 $V = 60.0\,\text{N}$, $M = -12{,}000\,\text{N}\cdot\text{mm} + (60.0\,\text{N})\,x$.

8.88 $V = 60.0\,\text{N}$, $M = -21{,}000\,\text{N}\cdot\text{mm} + (60.0\,\text{N})\,x$ for $0 \le x \le 150\,\text{mm}$; $V = 240\,\text{N}$, $M = -48{,}000\,\text{N}\cdot\text{mm} + (240\,\text{N})\,x$ for $150\,\text{mm} \le x \le 200\,\text{mm}$.

8.90 $V_{\max} = -1750\,\text{lb}$ for $15\,\text{ft} \le x \le 20\,\text{ft}$, $M_{\max} = 8750\,\text{ft}\cdot\text{lb}$ at $x = 15\,\text{ft}$.

8.92 **(a)** $V = -4.00\,\text{kN} - (\frac{1}{3}\,\text{kN/m}^2)\,x^2$; **(b)** $M = (-4.00\,\text{kN})\,x - (\frac{1}{9}\,\text{kN/m}^2)\,x^3$; **(c)** $V_{\max} = 9.00\,\text{kN}$ at $x = 3\,\text{m}$, $M_{\max} = -15.0\,\text{kN}\cdot\text{m}$ at $x = 3\,\text{m}$.

8.94 **(a)** $M = (-2.00\,\text{kip/ft})\,x^2$; **(b)** $V = 56.0\,\text{kip} - (8.00\,\text{kip/ft})\,x + (\frac{1}{3}\,\text{kip/ft}^2)\,x^2$; **(c)** $V_{\max} = 20.0\,\text{kip}$ at $x = 6\,\text{ft}$, $M_{\max} = -72.0\,\text{ft}\cdot\text{kip}$ at $x = 6\,\text{ft}$.

8.96 **(a)** $M = 132\,\text{kN}\cdot\text{m} - (17.0\,\text{kN})\,x + (0.500\,\text{kN/m})\,x^2$; **(b)** $V = 16.0\,\text{kN} - (4.00\,\text{kN/m})\,x + (\frac{1}{3}\,\text{kN/m}^2)\,x^2$; **(c)** $V_{\max} = 16.0\,\text{kN}$ at $x = 0$, $M_{\max} = 48.0\,\text{kN}\cdot\text{m}$ at $x = 6\,\text{m}$.

Chapter 9

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

9.4 $\mu \ge 0.0939$.

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

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

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

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

9.14 $N = 1.43\times10^6\,\text{lb}$, $F = 8.58\times10^4\,\text{lb}$.

9.16 $P = 47.4\,\text{N}$.

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

9.20 $\mu_s = 0.750$.

9.22 $P = 0.900\,\text{lb}$ will cause all books to slide.

9.24 $\mu_s = 0.417$.

9.26 $Q = 7.70\,\text{lb}$.

9.28 $P = 10.6\,\text{N}$.

9.30 $P = 7\,\text{kN}$.

9.32 $\mu_s = \frac{5}{3}$.

9.34 The truck is not capable of pulling the dumpster.

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

9.38 **(a)**, **(b)**, & **(c)** $P = 73.0\,\text{lb}$.

9.40 $M_A = 23.1\,\text{N}\cdot\text{m}$.

9.42 $M_A = 575\,\text{in.}\cdot\text{lb}$.

9.44 **(a)** $P = 14.1\,\text{N}$; **(b)** $P = 4.54\,\text{N}$.

9.46 $W = 35.3\,\text{lb}$.

9.48 $W_B = 53.8\,\text{lb}$, surface C will stick while motion is impending at A and B.

9.50 $\mu = 0.0741$.

9.52 $\mu = 0.0943$, the normal and friction forces between the dam and foundation are located $0.730\,\text{m}$ to the left of point A.

9.54 $P = 1.60\,\text{lb}$, the roll of paper will tip.

9.56 $P = 56.2\,\text{lb}$, slip is impending at E and there is no slip at B and C.

9.58 $T_0 = 57.4\,\text{lb}$.

Chapter 10

10.2 Essay-type answer.

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

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

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)** $I_x = 2.74\,\text{mm}^4$; **(b)** $I_y = 11.0\,\text{mm}^4$.

10.20 **(a)** $I_x = 0.305\,\text{mm}^4$; **(b)** $I_y = 1.60\,\text{mm}^4$.

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

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

10.26 $I_x = 0.305\,\text{mm}^4$.

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

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

10.32 $k_x = 23.1\,\text{in.}$

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

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

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

10.44 **(a)** $d = 2.00\,\text{mm}$; **(b)** $I_x = 88.0\,\text{mm}^4$; **(c)** $I_y = 48.0\,\text{mm}^4$.

10.46 **(a)** $d = 65.0\,\text{mm}$; **(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 $I_y = \frac{3}{5}m(\frac{1}{3}a^2 + h^2)$ 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)** $I_x = \frac{103}{640}\pi r^4\rho_0$.

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

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

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

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 $I_z = 0.619\,\text{slug}\cdot\text{in.}^2$.

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)** $d = 1.183\,\text{in.}$; **(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 $I_z = 16.7\,\text{slug}\cdot\text{in.}^2$.