ANSWERS TO SELECTED PROBLEMS

Chapter 2

2.1
$$\mathbf{C} = \begin{bmatrix} 8 & 17 & -3 \\ -1 & -1 & -1 \\ 1 & -7 & 1 \end{bmatrix}; \quad \mathbf{D} = \begin{bmatrix} -2 & -1 & 1 \\ 17 & -13 & -7 \\ -3 & -1 & 9 \end{bmatrix}$$

2.3
$$\mathbf{C} = -4; \quad \mathbf{D} = \begin{bmatrix} 12 & -18 & 6 \\ 4 & -6 & 2 \\ -2 & 30 & -10 \end{bmatrix}$$

2.5
$$\mathbf{C} = \begin{bmatrix} -18 & -24 & 21 \\ 7 & -9 & 53 \\ 38 & 38 & 58 \end{bmatrix}; \quad \mathbf{D} = \begin{bmatrix} -18 & 7 & 38 \\ -24 & -9 & 38 \\ 21 & 53 & 58 \end{bmatrix}$$

2.9 $(\mathbf{ABC})^T = \mathbf{C}^T\mathbf{B}^T\mathbf{A}^T$
$$= \begin{bmatrix} 1{,}512 & -464 & -1{,}602 & 1{,}418 \\ -900 & 5{,}300 & 200 & -2{,}100 \\ -810 & -310 & 942 & -620 \\ 270 & 410 & -360 & 130 \end{bmatrix}$$

2.11
$$\mathbf{C} = \begin{bmatrix} 332 & 76 & -332 & -76 \\ 76 & 168 & -76 & -168 \\ -332 & -76 & 332 & 76 \\ -76 & -168 & 76 & 168 \end{bmatrix}$$

2.13
$$\frac{d\mathbf{A}}{dx} = \begin{bmatrix} -4x & 3\cos x & -7 \\ 3\cos x & -2\sin x \cos x & -9x^2 \\ -7 & -9x^2 & 6\sin x \cos x \end{bmatrix}$$

2.15
$$\frac{d\mathbf{AB}}{dx} = \begin{bmatrix} -120x^3 & -20x - 60x^2 \\ -90x^2 & -2 - 8x + 45x^4 \\ -6 + 28x + 125x^4 & 28 + 24x^2 \end{bmatrix}$$

2.17
$$\int_0^L \mathbf{A}\, dx = \begin{bmatrix} -5L & -L^3 \\ 2L^2 & -\dfrac{L^4}{4} \\ \dfrac{2L^5}{5} & 6L \\ \dfrac{5L^3}{3} & -\dfrac{L^2}{2} \end{bmatrix}$$

2.19 $\displaystyle\int_0^L \mathbf{AB}\, dx$
$$= \begin{bmatrix} \dfrac{10L^3}{3} + \dfrac{9L^4}{4} + \dfrac{2L^5}{5} & -9L - L^4 - \dfrac{L^6}{6} \\ -3L^3 + \dfrac{6L^7}{7} & -\dfrac{L^4}{2} \end{bmatrix}$$

614

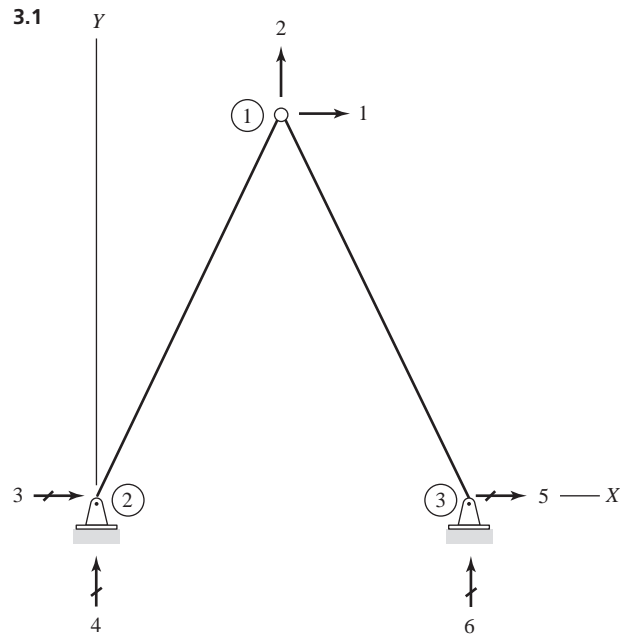**2.21** $x_1 = -2; x_2 = 3; x_3 = -5$

2.23 $x_1 = 8.7; x_2 = -7.5; x_3 = -4.2$
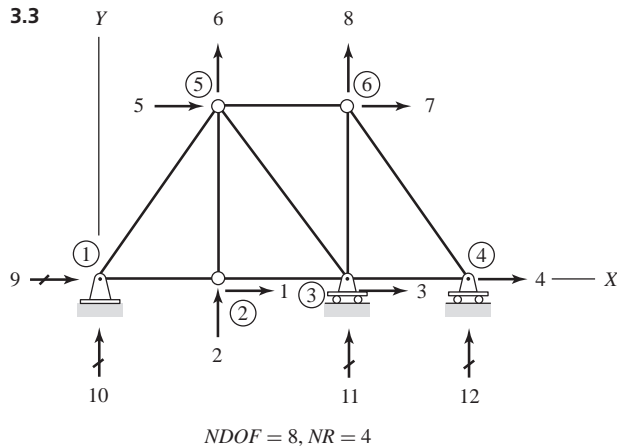
2.25 $x_1 = 6; x_2 = 7; x_3 = 5; x_4 = 2$

2.27
$$\mathbf{A}^{-1} = \begin{bmatrix} 0.44444 & -0.11111 & 0.22222 \\ -0.11111 & 0.16239 & -0.017094 \\ 0.22222 & -0.017094 & 0.26496 \end{bmatrix}$$

2.29
$$\mathbf{A}^{-1} = \begin{bmatrix} -0.62656 & -0.71396 & 0.2849 & -0.12372 \\ -0.71396 & -0.6958 & 0.2395 & -0.052213 \\ 0.2849 & 0.2395 & -0.098751 & 0.13053 \\ -0.12372 & -0.052213 & 0.13053 & -0.08059 \end{bmatrix}$$

Chapter 3

3.1

$NDOF = 2, NR = 4$

$$\mathbf{P} = \begin{bmatrix} 12 \\ -20 \end{bmatrix} \text{k}$$

3.3

$NDOF = 8, NR = 4$

$$\mathbf{P} = \begin{bmatrix} 0 \\ -30 \\ 0 \\ 0 \\ 10 \\ 0 \\ 0 \\ -30 \end{bmatrix} \text{k}$$

3.5

$$\mathbf{k}_1 = \mathbf{k}_3 = \begin{bmatrix} 483.33 & 0 & -483.33 & 0 \\ 0 & 0 & 0 & 0 \\ -483.33 & 0 & 483.33 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \text{k/in.}$$

$$\mathbf{k}_2 = \begin{bmatrix} 402.78 & 0 & -402.78 & 0 \\ 0 & 0 & 0 & 0 \\ -402.78 & 0 & 402.78 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \text{k/in.}$$

3.7 1,540 kN (T)

3.9

$$\mathbf{T}_1 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\mathbf{T}_2 = \begin{bmatrix} 0.6 & 0.8 & 0 & 0 \\ -0.8 & 0.6 & 0 & 0 \\ 0 & 0 & 0.6 & 0.8 \\ 0 & 0 & -0.8 & 0.6 \end{bmatrix}$$

$$\mathbf{T}_3 = \begin{bmatrix} -0.28 & 0.96 & 0 & 0 \\ -0.96 & -0.28 & 0 & 0 \\ 0 & 0 & -0.28 & 0.96 \\ 0 & 0 & -0.96 & -0.28 \end{bmatrix}$$

3.11 and 3.13

$$\mathbf{F}_9 = \begin{bmatrix} -560 \\ -420 \\ 560 \\ 420 \end{bmatrix} \text{kN;} \quad \text{Yes}$$

3.15 $\mathbf{S} = \begin{bmatrix} 666.23 & 63.413 \\ 63.413 & 703.22 \end{bmatrix}$ k/in.

3.17 $\mathbf{d} = \begin{bmatrix} 0.067082 \\ -0.027951 \end{bmatrix}$ in.

$Q_{a1} = 2.2361$ k (T); $Q_{a2} = 24.597$ k (C)

$$\mathbf{R} = \begin{bmatrix} -1 \\ -2 \\ -11 \\ 22 \end{bmatrix} \text{k}$$

3.19 $\mathbf{d} = \begin{bmatrix} -0.06546 \\ -0.10075 \end{bmatrix}$ in.

$Q_{a1} = 31.639$ k (C); $Q_{a2} = 48.283$ k (C);

$Q_{a3} = 37.889$ k (C)

$$\mathbf{R} = \begin{bmatrix} 28.97 \\ 38.627 \\ -10.609 \\ 36.373 \\ 31.639 \\ 0 \end{bmatrix} \text{k}$$

3.21 $\mathbf{d} = \begin{bmatrix} 0.2751 \\ -0.32051 \\ 0.23438 \end{bmatrix}$ in.

$Q_{a1} = 85.969$ k (T); $Q_{a2} = 133.55$ k (C);

$Q_{a3} = 46.875$ k (T); $Q_{a4} = 19.775$ k (C);

$Q_{a5} = 46.875$ k (T)

$$\mathbf{R} = \begin{bmatrix} -123.47 \\ 28.125 \\ -26.531 \\ -11.671 \\ 133.55 \end{bmatrix} \text{k}$$

3.23 $\mathbf{d} = \begin{bmatrix} 1.5685 \\ 0.78427 \\ -1.261 \\ 5.2564 \\ -1.5981 \end{bmatrix}$ mm

$Q_{a1} = 78.427$ kN (T); $Q_{a2} = Q_{a3} = 23.836$ kN (C);

$Q_{a4} = 41.205$ kN (T); $Q_{a5} = 33.709$ kN (C);

$Q_{a6} = 137.68$ kN (C)

$$\mathbf{R} = \begin{bmatrix} -80 \\ -20 \\ 140 \end{bmatrix} \text{kN}$$

3.25

$$\mathbf{d} = \begin{bmatrix} 0.019447 \\ -0.096374 \\ 0.038894 \\ 0.044168 \\ 0.031186 \\ -0.054995 \\ 0.025912 \\ -0.032004 \end{bmatrix} \text{in.}$$

$Q_{a1} = Q_{a2} = 18.799$ k (T); $Q_{a3} = 5.098$ k (T);
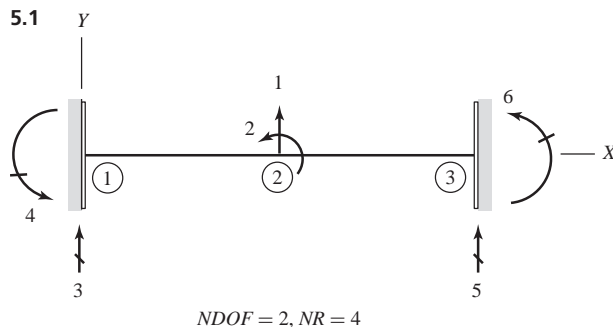
$Q_{a4} = 5.098$ k (C); $Q_{a5} = 30$ k (T);

$Q_{a6} = 23.203$ k (C);

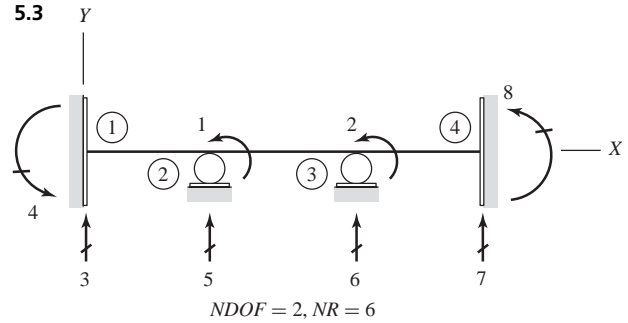$Q_{a7} = 14.665$ k (C); $Q_{a8} = 22.835$ k (C);

$Q_{a9} = 8.4966$ k (C)

$$\mathbf{R} = \begin{bmatrix} -10 \\ 11.732 \\ 41.471 \\ 6.7973 \end{bmatrix} \text{k}$$

3.29 $P = 1{,}095$ kN

Chapter 5

5.1

$NDOF = 2, NR = 4$

$$\mathbf{P} = \begin{bmatrix} -25\,\text{k} \\ 720\,\text{k-in.} \end{bmatrix}$$

5.3

$NDOF = 2, NR = 6$

$$\mathbf{P} = \begin{bmatrix} -150 \\ 0 \end{bmatrix} \text{kN} \cdot \text{m}$$

5.5 Units: kips and inches

$$\mathbf{k}_1 = \begin{bmatrix} 5.5556 & 500 & -5.5556 & 500 \\ 500 & 60{,}000 & -500 & 30{,}000 \\ -5.5556 & -500 & 5.5556 & -500 \\ 500 & 30{,}000 & -500 & 60{,}000 \end{bmatrix}$$

$$\mathbf{k}_2 = \begin{bmatrix} 11.111 & 1{,}000 & -11.111 & 1{,}000 \\ 1{,}000 & 120{,}000 & -1{,}000 & 60{,}000 \\ -11.111 & -1{,}000 & 11.111 & -1{,}000 \\ 1{,}000 & 60{,}000 & -1{,}000 & 120{,}000 \end{bmatrix}$$

5.7 Units: kips and inches

$$\mathbf{k}_1 = \mathbf{k}_4 = \begin{bmatrix} 9.4401 & 1{,}132.8 & -9.4401 & 1{,}132.8 \\ 1{,}132.8 & 181{,}250 & -1{,}132.8 & 90{,}625 \\ -9.4401 & -1{,}132.8 & 9.4401 & -1{,}132.8 \\ 1{,}132.8 & 90{,}625 & -1{,}132.8 & 181{,}250 \end{bmatrix}$$

$$\mathbf{k}_2 = \mathbf{k}_3 = \begin{bmatrix} 17.901 & 1{,}611.1 & -17.901 & 1{,}611.1 \\ 1{,}611.1 & 193{,}333 & -1{,}611.1 & 96{,}667 \\ -17.901 & -1{,}611.1 & 17.901 & -1{,}611.1 \\ 1{,}611.1 & 96{,}667 & -1{,}611.1 & 193{,}333 \end{bmatrix}$$

5.9

$$\mathbf{Q}_1 = \begin{bmatrix} 2.7848\,\text{k} \\ 1{,}002.5\,\text{k-in.} \\ -2.7848\,\text{k} \\ -501.23\,\text{k-in.} \end{bmatrix}; \text{ Yes}$$

5.11 $FS_b = FS_e = \dfrac{wL}{2}; \; FM_b = -FM_e = \dfrac{wL^2}{12}$

5.13 $FS_b = \dfrac{7wL}{20}; \; FM_b = \dfrac{wL^2}{20}; \; FS_e = \dfrac{3wL}{20}; \; FM_e = -\dfrac{wL^2}{30}$

5.15

$$\mathbf{Q}_{f1} = \begin{bmatrix} 135\,\text{kN} \\ 337.5\,\text{kN} \cdot \text{m} \\ 135\,\text{kN} \\ -337.5\,\text{kN} \cdot \text{m} \end{bmatrix} \quad \mathbf{Q}_{f2} = \begin{bmatrix} 90\,\text{kN} \\ 300\,\text{kN} \cdot \text{m} \\ 90\,\text{kN} \\ -300\,\text{kN} \cdot \text{m} \end{bmatrix}$$

$$\mathbf{Q}_{f3} = \begin{bmatrix} 131.25 \text{ kN} \\ 281.25 \text{ kN} \cdot \text{m} \\ 56.25 \text{ kN} \\ -187.5 \text{ kN} \cdot \text{m} \end{bmatrix}$$

$$\mathbf{Q}_1 = \begin{bmatrix} -20 \text{ kN} \\ -40 \text{ kN} \cdot \text{m} \\ 20 \text{ kN} \\ -80 \text{ kN} \cdot \text{m} \end{bmatrix} \quad \mathbf{Q}_2 = \begin{bmatrix} -15 \text{ kN} \\ -70 \text{ kN} \cdot \text{m} \\ 15 \text{ kN} \\ -20 \text{ kN} \cdot \text{m} \end{bmatrix}$$

5.17
$$\mathbf{Q}_1 = \begin{bmatrix} 69.52 \text{ k} \\ 4{,}945.9 \text{ k-in.} \\ 2.48 \text{ k} \\ 4{,}707.8 \text{ k-in.} \end{bmatrix}; \text{ Yes}$$

$$\mathbf{Q}_3 = \begin{bmatrix} 5 \text{ kN} \\ 20 \text{ kN} \cdot \text{m} \\ -5 \text{ kN} \\ 10 \text{ kN} \cdot \text{m} \end{bmatrix} \quad \mathbf{R} = \begin{bmatrix} -20 \text{ kN} \\ -40 \text{ kN} \cdot \text{m} \\ 5 \text{ kN} \\ 20 \text{ kN} \\ -5 \text{ kN} \\ 10 \text{ kN} \cdot \text{m} \end{bmatrix}$$

5.19 Units: kips and inches

$$\mathbf{S} = \begin{bmatrix} 16.667 & 500 \\ 500 & 180{,}000 \end{bmatrix}$$

5.21 Units: kips and inches

$$\mathbf{S} = \begin{bmatrix} 27.341 & 478.3 & 1{,}611.1 & 0 & 0 \\ 478.3 & 374{,}583 & 96{,}667 & 0 & 0 \\ 1{,}611.1 & 96{,}667 & 386{,}667 & -1{,}611.1 & 96{,}667 \\ 0 & 0 & -1{,}611.1 & 27.341 & -478.3 \\ 0 & 0 & 96{,}667 & -478.3 & 374{,}583 \end{bmatrix}$$

5.23 Units: kips and inches

$$\mathbf{P}_f = -\mathbf{P}_e = \begin{bmatrix} 0 \\ 30 \\ 360 \end{bmatrix}$$

5.25 Units: kN and meters

$$\mathbf{P}_f = -\mathbf{P}_e = \begin{bmatrix} 337.5 \\ -37.5 \\ -18.75 \\ -187.5 \end{bmatrix}$$

5.27
$$\mathbf{d} = \begin{bmatrix} -1.7673 \text{ in.} \\ 0.0089091 \text{ rad} \end{bmatrix}$$

$$\mathbf{Q}_1 = \begin{bmatrix} 14.273 \text{ k} \\ 1{,}150.9 \text{ k-in.} \\ -14.273 \text{ k} \\ 1{,}418.2 \text{ k-in.} \end{bmatrix} \quad \mathbf{Q}_2 = \begin{bmatrix} -10.727 \text{ k} \\ -698.18 \text{ k-in.} \\ 10.727 \text{ k} \\ -1{,}232.7 \text{ k-in.} \end{bmatrix}$$

$$\mathbf{R} = \begin{bmatrix} 14.273 \text{ k} \\ 1{,}150.9 \text{ k-in.} \\ 10.727 \text{ k} \\ -1{,}232.7 \text{ k-in.} \end{bmatrix}$$

5.29
$$\mathbf{d} = \begin{bmatrix} -0.007619 \\ 0.0019048 \end{bmatrix} \text{rad}$$

5.31
$$\mathbf{d} = \begin{bmatrix} 0.014375 \\ -0.011422 \\ 0.014244 \end{bmatrix} \text{rad}$$

$$\mathbf{Q}_1 = \begin{bmatrix} 41.615 \text{ k} \\ 2{,}267.1 \text{ k-in.} \\ 30.385 \text{ k} \\ -649.85 \text{ k-in.} \end{bmatrix} \quad \mathbf{Q}_2 = \begin{bmatrix} 1.1538 \text{ k} \\ 649.85 \text{ k-in.} \\ -1.1538 \text{ k} \\ -317.54 \text{ k-in.} \end{bmatrix}$$

$$\mathbf{Q}_3 = \begin{bmatrix} 11.103 \text{ k} \\ 317.54 \text{ k-in.} \\ 8.8974 \text{ k} \\ 0 \end{bmatrix} \quad \mathbf{R} = \begin{bmatrix} 41.615 \text{ k} \\ 2{,}267.1 \text{ k-in.} \\ 31.538 \text{ k} \\ 9.9487 \text{ k} \\ 8.8974 \text{ k} \end{bmatrix}$$

5.33
$$\mathbf{d} = \begin{bmatrix} -0.019391 \\ 0.0071406 \\ -0.0056563 \\ 0.017242 \end{bmatrix} \text{rad}$$

$$\mathbf{Q}_1 = \begin{bmatrix} 108.87 \text{ kN} \\ 0 \\ 161.13 \text{ kN} \\ -392 \text{ kN} \cdot \text{m} \end{bmatrix} \quad \mathbf{Q}_2 = \begin{bmatrix} 93.167 \text{ kN} \\ 392 \text{ kN} \cdot \text{m} \\ 86.833 \text{ kN} \\ -344.5 \text{ kN} \cdot \text{m} \end{bmatrix}$$

$$\mathbf{Q}_3 = \begin{bmatrix} 155.97 \text{ kN} \\ 344.5 \text{ kN} \cdot \text{m} \\ 31.533 \text{ kN} \\ 120 \text{ kN} \cdot \text{m} \end{bmatrix} \quad \mathbf{R} = \begin{bmatrix} 108.87 \\ 254.3 \\ 242.8 \\ 31.533 \end{bmatrix} \text{kN}$$

5.35
$$\mathbf{d} = \begin{bmatrix} -1.8705 \text{ in.} \\ 0.0023884 \text{ rad} \\ 0 \\ -1.8705 \text{ in.} \\ -0.0023884 \text{ rad} \end{bmatrix}$$
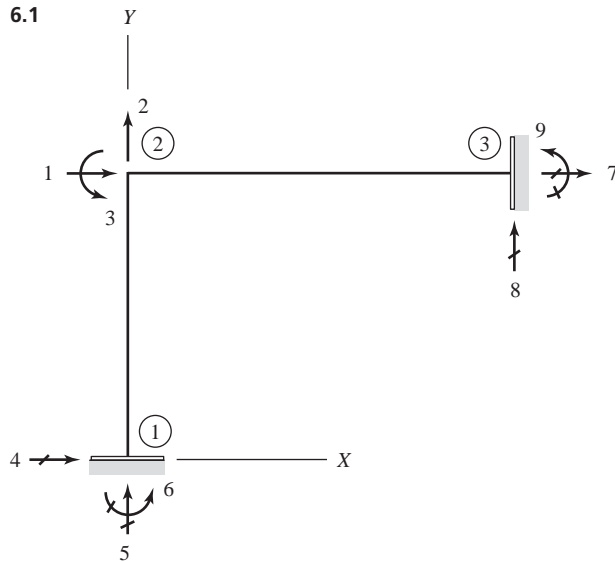
$$\mathbf{Q}_1 = \begin{bmatrix} 20.363 \text{ k} \\ 2{,}335.4 \text{ k-in.} \\ -20.363 \text{ k} \\ 2{,}551.8 \text{ k-in.} \end{bmatrix} \quad \mathbf{Q}_2 = \begin{bmatrix} -29.637 \text{ k} \\ -2{,}551.8 \text{ k-in.} \\ 29.637 \text{ k} \\ -2{,}782.7 \text{ k-in.} \end{bmatrix}$$

$$\mathbf{Q}_3 = \begin{bmatrix} 29.637 \text{ k} \\ 2{,}782.7 \text{ k-in.} \\ -29.637 \text{ k} \\ 2{,}551.8 \text{ k-in.} \end{bmatrix} \quad \mathbf{Q}_4 = \begin{bmatrix} -20.363 \text{ k} \\ -2{,}551.8 \text{ k-in.} \\ 20.363 \text{ k} \\ -2{,}335.4 \text{ k-in.} \end{bmatrix}$$

$$\mathbf{R} = \begin{bmatrix} 20.363 \text{ k} \\ 2{,}335.4 \text{ k-in.} \\ 59.273 \text{ k} \\ 20.363 \text{ k} \\ -2{,}335.4 \text{ k-in.} \end{bmatrix}$$

6.3

$$NDOF = 2, NR = 7$$
$$\mathbf{P} = \mathbf{0}$$

6.5

$$\mathbf{P} = \begin{bmatrix} 30 \text{ k} \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

Chapter 6

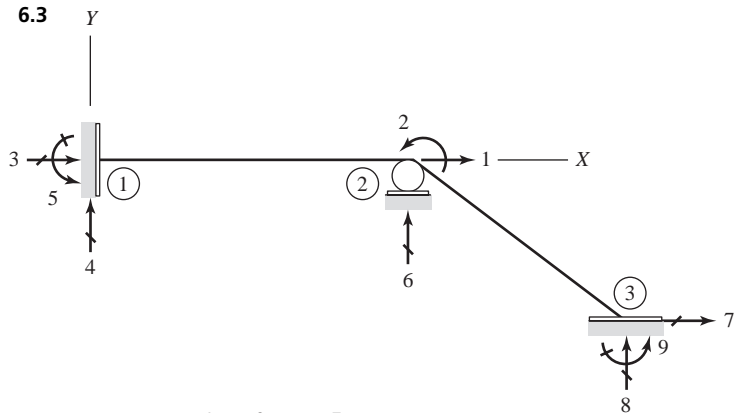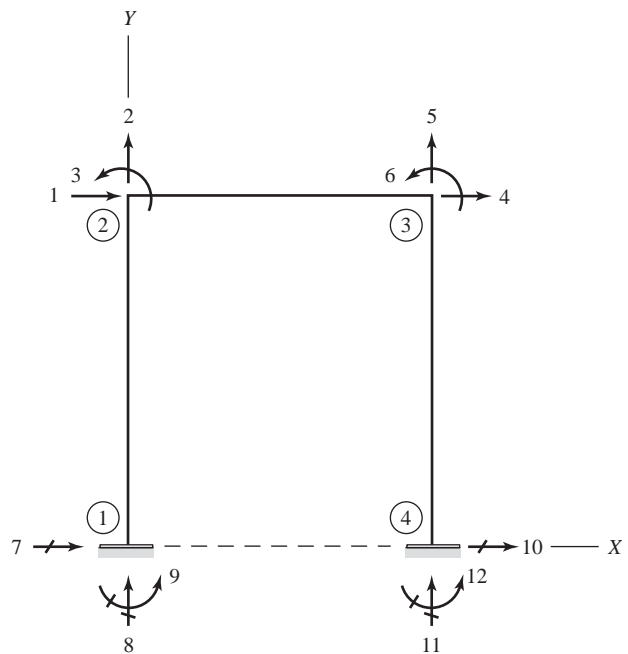**6.1**

$$NDOF = 3, NR = 6$$

$$\mathbf{P} = \begin{bmatrix} 0 \\ 0 \\ -900 \text{ k-in.} \end{bmatrix}$$

$$NDOF = 6, NR = 6$$

6.7 Units: kips and inches

$$
\mathbf{k}_1 = \begin{bmatrix}
1,244.6 & 0 & 0 & -1,244.6 & 0 & 0 \\
0 & 12.839 & 1,540.6 & 0 & -12.839 & 1,540.6 \\
0 & 1,540.6 & 246,500 & 0 & -1,540.6 & 123,250 \\
-1,244.6 & 0 & 0 & 1,244.6 & 0 & 0 \\
0 & -12.839 & -1,540.6 & 0 & 12.839 & -1,540.6 \\
0 & 1,540.6 & 123,250 & 0 & -1,540.6 & 246,500
\end{bmatrix}
$$

$$
\mathbf{k}_2 = \begin{bmatrix}
829.72 & 0 & 0 & -829.72 & 0 & 0 \\
0 & 3.804 & 684.72 & 0 & -3.804 & 684.72 \\
0 & 684.72 & 164,333 & 0 & -684.72 & 82,167 \\
-829.72 & 0 & 0 & 829.72 & 0 & 0 \\
0 & -3.804 & -684.72 & 0 & 3.804 & -684.72 \\
0 & 684.72 & 82,167 & 0 & -684.72 & 164,333
\end{bmatrix}
\qquad
\mathbf{Q}_{f1} = \begin{bmatrix} 0 \\ 20 \\ 1,200 \\ 0 \\ 20 \\ -1,200 \end{bmatrix}
\qquad
\mathbf{Q}_{f2} = \begin{bmatrix} 0 \\ 22.5 \\ 1,350 \\ 0 \\ 22.5 \\ -1,350 \end{bmatrix}
$$

6.9 Units: kips and inches

$$
\mathbf{k}_1 = \begin{bmatrix}
409.26 & 0 & 0 & -409.26 & 0 & 0 \\
0 & 2.0243 & 218.62 & 0 & -2.0243 & 218.62 \\
0 & 218.62 & 31,481 & 0 & -218.62 & 15,741 \\
-409.26 & 0 & 0 & 409.26 & 0 & 0 \\
0 & -2.0243 & -218.62 & 0 & 2.0243 & -218.62 \\
0 & 218.62 & 15,741 & 0 & -218.62 & 31,481
\end{bmatrix}
$$

$$
\mathbf{k}_2 = \begin{bmatrix}
491.11 & 0 & 0 & -491.11 & 0 & 0 \\
0 & 3.4979 & 314.81 & 0 & -3.4979 & 314.81 \\
0 & 314.81 & 37,778 & 0 & -314.81 & 18,889 \\
-491.11 & 0 & 0 & 491.11 & 0 & 0 \\
0 & -3.4979 & -314.81 & 0 & 3.4979 & -314.81 \\
0 & 314.81 & 18,889 & 0 & -314.81 & 37,778
\end{bmatrix}
\qquad
\mathbf{Q}_{f1} = \begin{bmatrix} 0 \\ 27 \\ 972 \\ 0 \\ 27 \\ -972 \end{bmatrix}
\qquad
\mathbf{Q}_{f2} = \begin{bmatrix} -4.5 \\ 6 \\ 270 \\ -4.5 \\ 6 \\ -270 \end{bmatrix}
$$

6.11 Units: kips and inches

$$
\mathbf{k}_1 = \mathbf{k}_3 = \begin{bmatrix}
1,500 & 0 & 0 & -1,500 & 0 & 0 \\
0 & 2.1484 & 257.81 & 0 & -2.1484 & 257.81 \\
0 & 257.81 & 41,250 & 0 & -257.81 & 20,625 \\
-1,500 & 0 & 0 & 1,500 & 0 & 0 \\
0 & -2.1484 & -257.81 & 0 & 2.1484 & -257.81 \\
0 & 257.81 & 20,625 & 0 & -257.81 & 41,250
\end{bmatrix}
$$

$$
\mathbf{k}_2 = \begin{bmatrix}
1,620 & 0 & 0 & -1,620 & 0 & 0 \\
0 & 2.6 & 390 & 0 & -2.6 & 390 \\
0 & 390 & 78,000 & 0 & -390 & 39,000 \\
-1,620 & 0 & 0 & 1,620 & 0 & 0 \\
0 & -2.6 & -390 & 0 & 2.6 & -390 \\
0 & 390 & 39,000 & 0 & -390 & 78,000
\end{bmatrix}
\qquad
\mathbf{Q}_{f1} = \mathbf{Q}_{f3} = \mathbf{0}; \qquad
\mathbf{Q}_{f2} = \begin{bmatrix} 0 \\ 25 \\ 1,250 \\ 0 \\ 25 \\ -1,250 \end{bmatrix}
$$

6.13
$$FA_b = \frac{Wl_2}{L}; \quad FA_e = \frac{Wl_1}{L};$$

$$FS_b = FS_e = FM_b = FM_e = 0$$

6.15

$$\mathbf{Q}_1 = \begin{bmatrix} 128.12 \text{ k} \\ -78.786 \text{ k} \\ -5,875 \text{ k-in.} \\ -128.12 \text{ k} \\ 98.786 \text{ k} \\ -5,179.3 \text{ k-in.} \end{bmatrix} \quad \mathbf{Q}_2 = \begin{bmatrix} 111.62 \text{ k} \\ 11.038 \text{ k} \\ 1,942.5 \text{ k-in.} \\ -140.46 \text{ k} \\ -80.268 \text{ k} \\ 5,179.3 \text{ k-in.} \end{bmatrix} \quad \mathbf{Q}_3 = \begin{bmatrix} -70.97 \text{ k} \\ -20.192 \text{ k} \\ -2,176.6 \text{ k-in.} \\ 70.97 \text{ k} \\ 20.192 \text{ k} \\ -1,942.5 \text{ k-in.} \end{bmatrix}; \text{ Yes}$$

6.17

$$\mathbf{T}_1 = \begin{bmatrix} -0.6 & 0.8 & 0 & 0 & 0 & 0 \\ -0.8 & -0.6 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & -0.6 & 0.8 & 0 \\ 0 & 0 & 0 & -0.8 & -0.6 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}; \quad \mathbf{T}_2 = \mathbf{I}$$

6.19

$$\mathbf{T}_1 = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \quad \mathbf{T}_2 = \begin{bmatrix} -0.96 & 0.28 & 0 & 0 & 0 & 0 \\ -0.28 & -0.96 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & -0.96 & 0.28 & 0 \\ 0 & 0 & 0 & -0.28 & -0.96 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

6.21

$$\mathbf{T}_1 = \begin{bmatrix} 0.44721 & 0.89443 & 0 & 0 & 0 & 0 \\ -0.89443 & 0.44721 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0.44721 & 0.89443 & 0 \\ 0 & 0 & 0 & -0.89443 & 0.44721 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \quad \mathbf{T}_2 = \mathbf{I}$$

6.23 and 6.31

$$\mathbf{v}_1 = \begin{bmatrix} 0 \\ 0 \\ 0 \\ -2.0939 \text{ in.} \\ -0.05147 \text{ in.} \\ 0.0079542 \text{ rad} \end{bmatrix} \quad \mathbf{v}_2 = \begin{bmatrix} -1.8078 \text{ in.} \\ -0.90922 \text{ in.} \\ 0.0028882 \text{ rad} \\ -2.0939 \text{ in.} \\ -0.05147 \text{ in.} \\ 0.0079542 \text{ rad} \end{bmatrix} \quad \mathbf{v}_3 = \begin{bmatrix} 0 \\ 0 \\ 0 \\ -1.8078 \text{ in.} \\ -0.90922 \text{ in.} \\ 0.0028882 \text{ rad} \end{bmatrix}$$

$$\mathbf{F}_1 = \begin{bmatrix} 78.786 \text{ k} \\ 128.12 \text{ k} \\ -5,875 \text{ k-in.} \\ -98.786 \text{ k} \\ -128.12 \text{ k} \\ -5,179.3 \text{ k-in.} \end{bmatrix} \quad \mathbf{F}_2 = \begin{bmatrix} -98.786 \text{ k} \\ -53.119 \text{ k} \\ 1,942.5 \text{ k-in.} \\ 98.786 \text{ k} \\ 128.12 \text{ k} \\ 5,179.3 \text{ k-in.} \end{bmatrix} \quad \mathbf{F}_3 = \begin{bmatrix} 51.214 \text{ k} \\ -53.119 \text{ k} \\ -2,176.6 \text{ k-in.} \\ -51.214 \text{ k} \\ 53.119 \text{ k} \\ -1,942.5 \text{ k-in.} \end{bmatrix}; \text{ Yes}$$

6.25 Units: kN and meters

$$
\mathbf{K}_1 =
\begin{bmatrix}
94{,}770 & -123{,}922 & -7{,}315.2 & -94{,}770 & 123{,}922 & -7{,}315.2 \\
 & 167{,}058 & -5{,}486.4 & 123{,}922 & -167{,}058 & -5{,}486.4 \\
 & & 60{,}960 & 7{,}315.2 & 5{,}486.4 & 30{,}480 \\
 & \text{(symmetric)} & & 94{,}770 & -123{,}922 & 7{,}315.2 \\
 & & & & 167{,}058 & 5{,}486.4 \\
 & & & & & 60{,}960
\end{bmatrix}
$$

$$
\mathbf{K}_2 =
\begin{bmatrix}
216{,}667 & 0 & 0 & -216{,}667 & 0 & 0 \\
 & 1{,}058.3 & 6{,}350 & 0 & -1{,}058.3 & 6{,}350 \\
 & & 50{,}800 & 0 & -6{,}350 & 25{,}400 \\
 & \text{(symmetric)} & & 216{,}667 & 0 & 0 \\
 & & & & 1{,}058.3 & -6{,}350 \\
 & & & & & 50{,}800
\end{bmatrix}
$$

$$
\mathbf{F}_{f1} =
\begin{bmatrix}
50 \\
37.5 \\
-156.25 \\
50 \\
37.5 \\
156.25
\end{bmatrix}
\qquad
\mathbf{F}_{f2} =
\begin{bmatrix}
0 \\
144 \\
288 \\
0 \\
144 \\
-288
\end{bmatrix}
$$

6.27 Units: kN and meters

$$
\mathbf{K}_1 =
\begin{bmatrix}
694.92 & 0 & -5{,}559.4 & -694.92 & 0 & -5{,}559.4 \\
 & 200{,}000 & 0 & 0 & -200{,}000 & 0 \\
 & & 59{,}300 & 5{,}559.4 & 0 & 29{,}650 \\
 & & & 694.92 & 0 & 5{,}559.4 \\
 & & & & 200{,}000 & 0 \\
 & & & & & 59{,}300
\end{bmatrix}
$$

$$
\mathbf{K}_2 =
\begin{bmatrix}
117{,}980 & -34{,}357 & -637.59 & -117{,}980 & 34{,}357 & -637.59 \\
 & 10{,}203 & -2{,}186 & 34{,}357 & -10{,}203 & -2{,}186 \\
 & & 37{,}952 & 637.59 & 2{,}186 & 18{,}976 \\
 & & & 117{,}980 & -34{,}357 & 637.59 \\
 & & & & 10{,}203 & 2{,}186 \\
 & & & & & 37{,}952
\end{bmatrix}
$$

$$
\mathbf{F}_{f1} = \mathbf{0}; \qquad
\mathbf{F}_{f2} =
\begin{bmatrix}
0 \\
250 \\
-1{,}000 \\
0 \\
250 \\
1{,}000
\end{bmatrix}
$$

6.29 Units: kips and inches

$$\mathbf{K}_1 = \begin{bmatrix} 78.188 & 152.84 & -212.43 & -78.188 & -152.84 & -212.43 \\ & 307.44 & 106.21 & -152.84 & -307.44 & 106.21 \\ & & 42,485 & 212.43 & -106.21 & 21,243 \\ & \text{(symmetric)} & & 78.188 & 152.84 & 212.43 \\ & & & & 307.44 & -106.21 \\ & & & & & 42,485 \end{bmatrix}$$

$$\mathbf{K}_2 = \begin{bmatrix} 304 & 0 & 0 & -304 & 0 & 0 \\ & 1.6667 & 250 & 0 & -1.6667 & 250 \\ & & 50,000 & 0 & -250 & 25,000 \\ & \text{(symmetric)} & & 304 & 0 & 0 \\ & & & & 1.6667 & -250 \\ & & & & & 50,000 \end{bmatrix}$$

$$\mathbf{F}_{f1} = \begin{bmatrix} 0 \\ 11.18 \\ 223.61 \\ 0 \\ 11.18 \\ -223.61 \end{bmatrix} \qquad \mathbf{F}_{f2} = \begin{bmatrix} 0 \\ 16.25 \\ 875 \\ 0 \\ 21.25 \\ -1,000 \end{bmatrix}$$

6.33 Units: kN and meters

$$\mathbf{S} = \begin{bmatrix} 311,437 & -7,315.2 & 0 \\ -7,315.2 & 111,760 & 25,400 \\ 0 & 25,400 & 50,800 \end{bmatrix} \qquad \mathbf{P}_f = -\mathbf{P}_e = \begin{bmatrix} 50 \\ 131.75 \\ -288 \end{bmatrix}$$

6.35 Units: kN and meters

$$\mathbf{S} = \begin{bmatrix} 210,203 & -2,186 \\ -2,186 & 97,252 \end{bmatrix} \qquad \mathbf{P}_f = -\mathbf{P}_e = \begin{bmatrix} 250 \\ -1,000 \end{bmatrix}$$

6.37 Units: kips and inches

$$\mathbf{S} = \begin{bmatrix} 382.19 & 152.84 & 212.43 & 0 \\ 152.84 & 309.11 & 143.79 & 250 \\ 212.43 & 143.79 & 92,485 & 25,000 \\ 0 & 250 & 25,000 & 50,000 \end{bmatrix} \qquad \mathbf{P}_f = -\mathbf{P}_e = \begin{bmatrix} 0 \\ 27.431 \\ 651.4 \\ -1,000 \end{bmatrix}$$

6.39

$$\mathbf{P} = \begin{bmatrix} 0 \\ 0 \\ -30 \text{ k} \\ -180 \text{ k-in.} \\ 45 \text{ k} \\ 0 \\ 240 \text{ k-in.} \\ 0 \end{bmatrix}$$

6.41 $\mathbf{d} = \begin{bmatrix} 0.0034433 \text{ in.} \\ 0.0029828 \text{ rad} \end{bmatrix}$

$\mathbf{Q}_1 = \begin{bmatrix} -7.3457 \text{ k} \\ 16.132 \text{ k} \\ 517.88 \text{ k-in.} \\ 7.3457 \text{ k} \\ 13.869 \text{ k} \\ -314.26 \text{ k-in.} \end{bmatrix}$
$\mathbf{Q}_2 = \begin{bmatrix} 3.2599 \text{ k} \\ 9.3161 \text{ k} \\ 314.26 \text{ k-in.} \\ -3.2599 \text{ k} \\ 0.43406 \text{ k} \\ -1.7167 \text{ k-in.} \end{bmatrix}$

$\mathbf{R} = \begin{bmatrix} -7.3457 \text{ k} \\ 16.132 \text{ k} \\ 517.88 \text{ k-in.} \\ 20.461 \text{ k} \\ -1.6545 \text{ k} \\ -2.8422 \text{ k} \\ -1.7167 \text{ k-in.} \end{bmatrix}$

6.43 $\mathbf{d} = \begin{bmatrix} -0.00026195 \text{ m} \\ -0.0043172 \text{ rad} \\ 0.0078279 \text{ rad} \end{bmatrix}$

$\mathbf{Q}_1 = \begin{bmatrix} 40.864 \text{ kN} \\ -101.59 \text{ kN} \\ -417.51 \text{ kN} \cdot \text{m} \\ -40.864 \text{ kN} \\ -23.406 \text{ kN} \\ 26.577 \text{ kN} \cdot \text{m} \end{bmatrix}$
$\mathbf{Q}_2 = \begin{bmatrix} -56.756 \text{ kN} \\ 166.29 \text{ kN} \\ 267.51 \text{ kN} \cdot \text{m} \\ 56.756 \text{ kN} \\ 121.71 \text{ kN} \\ 0 \end{bmatrix}$

$\mathbf{R} = \begin{bmatrix} 43.244 \text{ kN} \\ -18.648 \text{ kN} \\ 26.577 \text{ kN} \cdot \text{m} \\ 259.94 \text{ kN} \\ 56.756 \text{ kN} \\ 121.71 \text{ kN} \end{bmatrix}$

6.45 $\mathbf{d} = \begin{bmatrix} -0.0010826 \text{ m} \\ 0.010258 \text{ rad} \end{bmatrix}$

$\mathbf{Q}_1 = \begin{bmatrix} 216.53 \text{ kN} \\ 57.029 \text{ kN} \\ 304.16 \text{ kN} \cdot \text{m} \\ -216.53 \text{ kN} \\ -57.029 \text{ kN} \\ 608.31 \text{ kN} \cdot \text{m} \end{bmatrix}$
$\mathbf{Q}_2 = \begin{bmatrix} 31.198 \text{ kN} \\ -216.45 \text{ kN} \\ -608.31 \text{ kN} \cdot \text{m} \\ 108.8 \text{ kN} \\ -263.55 \text{ kN} \\ 1,197 \text{ kN} \cdot \text{m} \end{bmatrix}$

$\mathbf{R} = \begin{bmatrix} -57.029 \text{ kN} \\ 216.53 \text{ kN} \\ 304.16 \text{ kN} \cdot \text{m} \\ 87.686 \text{ kN} \\ -30.656 \text{ kN} \\ 283.47 \text{ kN} \\ 1,197 \text{ kN} \cdot \text{m} \end{bmatrix}$

6.47 $\mathbf{d} = \begin{bmatrix} 0.062194 \text{ in.} \\ -0.13533 \text{ in.} \\ -0.014529 \text{ rad} \\ 0.027941 \text{ rad} \end{bmatrix}$

$\mathbf{Q}_1 = \begin{bmatrix} 45.788 \text{ k} \\ 1.7551 \text{ k} \\ -57.433 \text{ k-in.} \\ -25.787 \text{ k} \\ 8.245 \text{ k} \\ -813.28 \text{ k-in.} \end{bmatrix}$
$\mathbf{Q}_2 = \begin{bmatrix} 18.907 \text{ k} \\ 19.378 \text{ k} \\ 813.28 \text{ k-in.} \\ -18.907 \text{ k} \\ 18.123 \text{ k} \\ 0 \end{bmatrix}$

$\mathbf{R} = \begin{bmatrix} 18.907 \text{ k} \\ 41.739 \text{ k} \\ -57.433 \text{ k-in.} \\ -18.907 \text{ k} \\ 18.123 \text{ k} \end{bmatrix}$

6.49 $\mathbf{d} = \begin{bmatrix} 2.8978 \text{ in.} \\ -0.02114 \text{ in.} \\ -0.011687 \text{ rad} \\ 3.5004 \text{ in.} \\ -1.2117 \text{ in.} \\ 0.0038711 \text{ rad} \\ 4.0922 \text{ in.} \\ -0.029507 \text{ in.} \\ -0.0038888 \text{ rad} \end{bmatrix}$
$\mathbf{R} = \begin{bmatrix} -12.797 \text{ k} \\ 42.573 \text{ k} \\ 2,693.5 \text{ k-in.} \\ -37.203 \text{ k} \\ 59.424 \text{ k} \\ 5,640.4 \text{ k-in.} \end{bmatrix}$

$\mathbf{Q}_1 = \begin{bmatrix} 42.573 \text{ k} \\ 12.797 \text{ k} \\ 2,693.5 \text{ k-in.} \\ -42.573 \text{ k} \\ -12.797 \text{ k} \\ 991.87 \text{ k-in.} \end{bmatrix}$
$\mathbf{Q}_2 = \begin{bmatrix} 52.861 \text{ k} \\ 20.057 \text{ k} \\ -991.87 \text{ k-in.} \\ -28.861 \text{ k} \\ 24.941 \text{ k} \\ -4.395 \text{ k-in.} \end{bmatrix}$

$\mathbf{Q}_3 = \begin{bmatrix} 60.791 \text{ k} \\ -34.925 \text{ k} \\ -5,074.2 \text{ k-in.} \\ -36.791 \text{ k} \\ -10.073 \text{ k} \\ 4.395 \text{ k-in.} \end{bmatrix}$
$\mathbf{Q}_4 = \begin{bmatrix} 59.424 \text{ k} \\ 37.203 \text{ k} \\ 5,640.4 \text{ k-in.} \\ -59.424 \text{ k} \\ -37.203 \text{ k} \\ 5,074.2 \text{ k-in.} \end{bmatrix}$

Chapter 7

7.1 $\mathbf{d} = [-2.6519] \text{ in.}$

$\mathbf{Q}_1 = \begin{bmatrix} 24.591 \text{ k} \\ 2,301.9 \text{ k-in.} \\ 5.4087 \text{ k} \\ 0 \end{bmatrix}$
$\mathbf{Q}_2 = \begin{bmatrix} -5.4087 \text{ k} \\ 0 \\ 27.909 \text{ k} \\ -2,998.6 \text{ k-in.} \end{bmatrix}$

$$\mathbf{R} = \begin{bmatrix} 24.591 \text{ k} \\ 2,301.9 \text{ k-in.} \\ 0 \\ 27.909 \text{ k} \\ -2,998.6 \text{ k-in.} \end{bmatrix}$$

$$\mathbf{R} = \begin{bmatrix} 43.244 \text{ kN} \\ -18.648 \text{ kN} \\ 26.577 \text{ kN} \cdot \text{m} \\ 259.94 \text{ kN} \\ 56.756 \text{ kN} \\ 121.71 \text{ kN} \\ 0 \end{bmatrix}$$

7.3 $\mathbf{d} = \begin{bmatrix} 0.014375 \\ -0.011422 \end{bmatrix}$ rad

7.9 $\mathbf{d} = \begin{bmatrix} -0.000901 \text{ m} \\ -0.003276 \text{ m} \\ 0.010155 \text{ rad} \end{bmatrix}$

$$\mathbf{Q}_1 = \begin{bmatrix} 41.615 \text{ k} \\ 2,267.1 \text{ k-in.} \\ 30.385 \text{ k} \\ -649.85 \text{ k-in.} \end{bmatrix} \quad \mathbf{Q}_2 = \begin{bmatrix} 1.1538 \text{ k} \\ 649.85 \text{ k-in.} \\ -1.1538 \text{ k} \\ -317.54 \text{ k-in.} \end{bmatrix}$$

$$\mathbf{Q}_1 = \begin{bmatrix} 94.605 \text{ kN} \\ 46.434 \text{ kN} \\ 0 \\ -94.605 \text{ kN} \\ 73.566 \text{ kN} \\ -135.66 \text{ kN} \cdot \text{m} \end{bmatrix} \quad \mathbf{Q}_2 = \begin{bmatrix} 175.62 \text{ kN} \\ -13.456 \text{ kN} \\ 0 \\ -115.62 \text{ kN} \\ -31.544 \text{ kN} \\ 135.66 \text{ kN} \cdot \text{m} \end{bmatrix}$$

$$\mathbf{Q}_3 = \begin{bmatrix} 11.103 \text{ k} \\ 317.54 \text{ k-in.} \\ 8.8974 \text{ k} \\ 0 \end{bmatrix} \quad \mathbf{R} = \begin{bmatrix} 41.615 \text{ k} \\ 2,267.1 \text{ k-in.} \\ 31.538 \text{ k} \\ 9.9487 \text{ k} \\ 8.8974 \text{ k} \\ 0 \end{bmatrix}$$

$$\mathbf{R} = \begin{bmatrix} 94.605 \text{ kN} \\ 46.434 \text{ kN} \\ 0 \\ -94.605 \text{ kN} \\ 148.57 \text{ kN} \\ 0 \end{bmatrix}$$

7.5 $\mathbf{d} = \begin{bmatrix} 0.0071406 \\ -0.0056563 \\ 0.017242 \end{bmatrix}$ rad

7.11 $P_{\text{max}} = 951.36 \text{ kN}$

7.13 $P_{\text{max}} = 47.453 \text{ kN}$

$$\mathbf{Q}_1 = \begin{bmatrix} 108.87 \text{ kN} \\ 0 \\ 161.13 \text{ kN} \\ -392 \text{ kN} \cdot \text{m} \end{bmatrix} \quad \mathbf{Q}_2 = \begin{bmatrix} 93.167 \text{ kN} \\ 392 \text{ kN} \cdot \text{m} \\ 86.833 \text{ kN} \\ -344.5 \text{ kN} \cdot \text{m} \end{bmatrix}$$

7.17 $\mathbf{d} = \begin{bmatrix} 0.23122 \\ -0.36987 \\ 0.14063 \end{bmatrix}$ in.

$Q_{a1} = 72.258 \text{ k (T)}; \ Q_{a2} = 154.11 \text{ k (C)};$

$Q_{a3} = 28.125 \text{ k (T)}; \ Q_{a4} = 4.9438 \text{ k (T)};$

$Q_{a5} = 65.625 \text{ k (T)}$

$$\mathbf{Q}_3 = \begin{bmatrix} 155.97 \text{ kN} \\ 344.5 \text{ kN} \cdot \text{m} \\ 31.533 \text{ kN} \\ 120 \text{ kN} \cdot \text{m} \end{bmatrix} \quad \mathbf{R} = \begin{bmatrix} 108.87 \text{ kN} \\ 0 \\ 254.3 \text{ kN} \\ 242.8 \text{ kN} \\ 31.533 \text{ kN} \end{bmatrix}$$

$$\mathbf{R} = \begin{bmatrix} -94.758 \\ 16.875 \\ -55.242 \\ -43.489 \\ 176.61 \end{bmatrix} \text{k}$$

7.7 $\mathbf{d} = \begin{bmatrix} -0.00026195 \text{ m} \\ -0.0043172 \text{ rad} \end{bmatrix}$

7.19 $\mathbf{d} = \begin{bmatrix} -0.0036571 \\ 0.0017714 \end{bmatrix}$ rad

$$\mathbf{Q}_1 = \begin{bmatrix} 40.864 \text{ kN} \\ -101.59 \text{ kN} \\ -417.51 \text{ kN} \cdot \text{m} \\ -40.864 \text{ kN} \\ -23.406 \text{ kN} \\ 26.577 \text{ kN} \cdot \text{m} \end{bmatrix} \quad \mathbf{Q}_2 = \begin{bmatrix} -56.756 \text{ kN} \\ 166.29 \text{ kN} \\ 267.51 \text{ kN} \cdot \text{m} \\ 56.756 \text{ kN} \\ 121.71 \text{ kN} \\ 0 \end{bmatrix}$$

$$\mathbf{Q}_1 = \begin{bmatrix} -4.87 \text{ kN} \\ -1.8939 \text{ kN} \cdot \text{m} \\ 4.87 \text{ kN} \\ -32.196 \text{ kN} \cdot \text{m} \end{bmatrix} \quad \mathbf{Q}_2 = \begin{bmatrix} 15.624 \text{ kN} \\ 32.196 \text{ kN} \cdot \text{m} \\ -15.624 \text{ kN} \\ 77.176 \text{ kN} \cdot \text{m} \end{bmatrix}$$

$$\mathbf{Q}_3 = \begin{bmatrix} -24.147 \text{ kN} \\ -77.176 \text{ kN} \cdot \text{m} \\ 24.147 \text{ kN} \\ -91.853 \text{ kN.m} \end{bmatrix} \quad \mathbf{R} = \begin{bmatrix} -4.87 \text{ kN} \\ -1.8939 \text{ kN} \cdot \text{m} \\ 20.494 \text{ kN} \\ -39.771 \text{ kN} \\ 24.147 \text{ kN} \\ -91.853 \text{ kN} \cdot \text{m} \end{bmatrix}$$

7.21

$$\mathbf{d} = \begin{bmatrix} -2.6114 \text{ in.} \\ -0.0020419 \text{ rad} \\ 0 \\ -22.6114 \text{ in.} \\ 0.0020419 \text{ rad} \end{bmatrix}$$

$$\mathbf{Q}_1 = \begin{bmatrix} 22.339 \text{ k} \\ 2,773.2 \text{ k-in.} \\ -22.339 \text{ k} \\ 2,588.2 \text{ k-in.} \end{bmatrix} \quad \mathbf{Q}_2 = \begin{bmatrix} -27.661 \text{ k} \\ -2,588.2 \text{ k-in.} \\ 27.661 \text{ k} \\ -2,390.8 \text{ k-in.} \end{bmatrix}$$

$$\mathbf{Q}_3 = \begin{bmatrix} 27.661 \text{ k} \\ 2,390.8 \text{ k-in.} \\ -27.661 \text{ k} \\ 2,588.2 \text{ k-in.} \end{bmatrix} \quad \mathbf{Q}_4 = \begin{bmatrix} -22.339 \text{ k} \\ -2,588.2 \text{ k-in.} \\ 22.339 \text{ k} \\ -2,773.2 \text{ k-in.} \end{bmatrix}$$

$$\mathbf{R} = \begin{bmatrix} 22.339 \text{ k} \\ 2,773.2 \text{ k-in.} \\ 55.322 \text{ k} \\ 22.339 \text{ k} \\ -2,773.2 \text{ k-in.} \end{bmatrix}$$

7.23

$$\mathbf{d} = \begin{bmatrix} -0.00089687 \text{ m} \\ -0.053264 \text{ m} \\ 0.0071551 \text{ rad} \end{bmatrix}$$

$$\mathbf{Q}_1 = \begin{bmatrix} 94.171 \text{ kN} \\ 46.707 \text{ kN} \\ 0 \\ -94.171 \text{ kN} \\ 73.293 \text{ kN} \\ -132.93 \text{ kN} \cdot \text{m} \end{bmatrix} \quad \mathbf{Q}_2 = \begin{bmatrix} 175.14 \text{ kN} \\ -13.638 \text{ kN} \\ 0 \\ -115.14 \text{ kN} \\ -31.362 \text{ kN} \\ 132.93 \text{ kN} \cdot \text{m} \end{bmatrix}$$

$$\mathbf{R} = \begin{bmatrix} 94.171 \text{ kN} \\ 46.707 \text{ kN} \\ 0 \\ -94.171 \text{ kN} \\ 148.29 \text{ kN} \\ 0 \end{bmatrix}$$

7.29

$$\mathbf{d} = \begin{bmatrix} 0.30484 \\ -0.15602 \\ 0.17587 \end{bmatrix} \text{ in.}$$

$Q_{a1} = 95.262$ k (T); $Q_{a2} = 119.61$ k (C);

$Q_{a3} = 35.175$ k (T); $Q_{a4} = 36.527$ k (C);

$Q_{a5} = 58.575$ k (T)

$$\mathbf{R} = \begin{bmatrix} -123.4 \\ 21.105 \\ -26.598 \\ -4.7525 \\ 133.65 \end{bmatrix} \text{k}$$

7.31

$$\mathbf{d} = \begin{bmatrix} 0.0053481 \text{ m} \\ 0.0035829 \text{ m} \\ -0.00056336 \text{ rad} \end{bmatrix}$$

$$\mathbf{Q}_1 = \begin{bmatrix} 8.7792 \text{ kN} \\ -4.3505 \text{ kN} \\ -16.873 \text{ kN} \cdot \text{m} \\ -8.7792 \text{ kN} \\ 4.3505 \text{ kN} \\ -22.282 \text{ kN} \cdot \text{m} \end{bmatrix} \quad \mathbf{Q}_2 = \begin{bmatrix} 4.3505 \text{ kN} \\ 8.7792 \text{ kN} \\ 30.394 \text{ kN} \cdot \text{m} \\ -4.3505 \text{ kN} \\ -8.7792 \text{ kN} \\ 22.282 \text{ kN} \cdot \text{m} \end{bmatrix}$$

$$\mathbf{R} = \begin{bmatrix} 8.7792 \text{ kN} \\ -4.3505 \text{ kN} \\ -16.873 \text{ kN} \cdot \text{m} \\ -8.7792 \text{ kN} \\ 4.3505 \text{ kN} \\ 30.394 \text{ kN} \cdot \text{m} \end{bmatrix}$$

7.33

$$\mathbf{d} = \begin{bmatrix} -0.0068989 \text{ m} \\ -0.01902 \text{ m} \\ 0.0095899 \text{ rad} \end{bmatrix}$$

$$\mathbf{Q}_1 = \begin{bmatrix} 94.386 \text{ kN} \\ 46.572 \text{ kN} \\ 0 \\ -94.386 \text{ kN} \\ 73.428 \text{ kN} \\ -134.28 \text{ kN} \cdot \text{m} \end{bmatrix} \quad \mathbf{Q}_2 = \begin{bmatrix} 175.37 \text{ kN} \\ -13.548 \text{ kN} \\ 0 \\ -115.37 \text{ kN} \\ -31.452 \text{ kN} \\ 134.28 \text{ kN} \cdot \text{m} \end{bmatrix}$$

$$\mathbf{R} = \begin{bmatrix} 94.386 \text{ kN} \\ 46.572 \text{ kN} \\ 0 \\ -94.386 \text{ kN} \\ 148.43 \text{ kN} \\ 0 \end{bmatrix}$$

Chapter 8

8.1

$$\mathbf{d} = \begin{bmatrix} 17.871 \\ -5.0794 \\ -7.7663 \end{bmatrix} \text{mm}$$

$Q_{a1} = 24.768$ kN (T); $Q_{a2} = 93.974$ kN (C);

$Q_{a3} = 107$ kN (C)

$$\mathbf{R} = \begin{bmatrix} -5.5693 \\ -22.277 \\ 9.2822 \\ -52.351 \\ 69.802 \\ -34.901 \\ -17.079 \\ 102.48 \\ 25.619 \end{bmatrix} \text{kN}$$

8.3

$$\mathbf{d} = \begin{bmatrix} 1.0795 \\ -0.59449 \\ -1.4492 \end{bmatrix} \text{mm}$$

$Q_{a1} = 12.47$ kN (T); $Q_{a2} = 15.37$ kN (T);

$Q_{a3} = 67.569$ kN (C); $Q_{a4} = 81.813$ kN (C)

$$\mathbf{R} = \begin{bmatrix} -7.7899 \\ -9.7373 \\ 0 \\ 0 \\ -13.179 \\ 7.9076 \\ -42.21 \\ 52.763 \\ 0 \\ 0 \\ 70.154 \\ 42.092 \end{bmatrix} \text{kN}$$

8.5

$$\mathbf{d} = \begin{bmatrix} 4.3357 \\ -1.8141 \\ 1.5783 \\ 4.0207 \\ -1.5814 \\ -1.6683 \\ 0.77404 \\ -0.79219 \\ -1.5783 \\ 0.86404 \\ -0.97997 \\ 1.6683 \end{bmatrix} \text{mm} \quad \mathbf{R} = \begin{bmatrix} -15.75 \\ 33.75 \\ -6.75 \\ -29.25 \\ 146.25 \\ -29.25 \\ -51.75 \\ 146.25 \\ 29.25 \\ 6.75 \\ 33.75 \\ 6.75 \end{bmatrix} \text{kN}$$

$Q_{a1} = Q_{a3} = 93.531$ kN (C); $Q_{a2} = 151.99$ kN (C);

$Q_{a4} = 35.074$ kN (C); $Q_{a5} = 66.556$ kN (T);

$Q_{a6} = Q_{a8} = 0$; $Q_{a7} = 66.556$ kN (C);

$Q_{a9} = 63$ kN (C); $Q_{a10} = Q_{a11} = Q_{a12} = 18$ kN (C)

8.7

$$\mathbf{d} = \begin{bmatrix} -0.011755 \\ 0.011755 \end{bmatrix} \text{rad}$$

$$\mathbf{Q}_1 = \begin{bmatrix} 13.758 \text{ k} \\ 36.56 \text{ k-in.} \\ 487.97 \text{ k-in.} \\ 8.7422 \text{ k} \\ -36.56 \text{ k-in.} \\ -36.56 \text{ k-in.} \end{bmatrix} \quad \mathbf{Q}_2 = \begin{bmatrix} 8.7422 \text{ k} \\ -36.56 \text{ k-in.} \\ 36.56 \text{ k-in.} \\ 13.758 \text{ k} \\ 36.56 \text{ k-in.} \\ -487.97 \text{ k-in.} \end{bmatrix}$$

$$\mathbf{R} = \begin{bmatrix} 13.758 \text{ k} \\ 36.56 \text{ k-in.} \\ 487.97 \text{ k-in.} \\ 17.484 \text{ k} \\ 13.758 \text{ k} \\ -487.97 \text{ k-in.} \\ -36.56 \text{ k-in.} \end{bmatrix}$$

8.9

$$\mathbf{d} = \begin{bmatrix} -3.4115 \text{ in.} \\ 0.038485 \text{ rad} \\ 0.02126 \text{ rad} \end{bmatrix}$$

$$\mathbf{Q}_1 = \begin{bmatrix} 46.509 \text{ k} \\ -18.507 \text{ k-in.} \\ 8,177.2 \text{ k-in.} \\ -46.509 \text{ k} \\ 18.507 \text{ k-in.} \\ -1,479.9 \text{ k-in.} \end{bmatrix} \quad \mathbf{Q}_2 = \begin{bmatrix} -13.491 \text{ k} \\ 20.1 \text{ k-in.} \\ -18.508 \text{ k-in.} \\ 13.491 \text{ k} \\ -20.1 \text{ k-in.} \\ -3,219.4 \text{ k-in.} \end{bmatrix}$$

$$\mathbf{R} = \begin{bmatrix} 46.509 \text{ k} \\ -8{,}177.2 \text{ k-in.} \\ -18.507 \text{ k-in.} \\ 13.491 \text{ k} \\ -20.1 \text{ k-in.} \\ -3{,}219.4 \text{ k-in.} \end{bmatrix}$$

8.11

$$\mathbf{d} = \begin{bmatrix} -0.77317 \text{ in.} \\ 0.011346 \text{ rad} \\ -0.0032328 \text{ rad} \\ -4.529 \text{ in.} \\ 0.0092457 \text{ rad} \\ -0.017808 \text{ rad} \end{bmatrix}$$

$$\mathbf{Q}_1 = \begin{bmatrix} 7.5755 \text{ k} \\ -14.969 \text{ k-in.} \\ 2{,}746.4 \text{ k-in.} \\ -7.5755 \text{ k} \\ 14.969 \text{ k-in.} \\ -19.229 \text{ k-in.} \end{bmatrix}$$

$$\mathbf{Q}_2 = \begin{bmatrix} 7.5755 \text{ k} \\ 19.229 \text{ k-in.} \\ 14.969 \text{ k-in.} \\ 22.425 \text{ k} \\ -19.229 \text{ k-in.} \\ 12.198 \text{ k-in.} \end{bmatrix}$$

$$\mathbf{Q}_3 = \begin{bmatrix} 82.425 \text{ k} \\ -12.198 \text{ k-in.} \\ 18{,}854 \text{ k-in.} \\ -22.425 \text{ k} \\ 12.198 \text{ k-in.} \\ 19.228 \text{ k-in.} \end{bmatrix}$$

$$\mathbf{R} = \begin{bmatrix} 7.5755 \text{ k} \\ -14.969 \text{ k-in.} \\ 2{,}746.4 \text{ k-in.} \\ 82.425 \text{ k} \\ -12.198 \text{ k-in.} \\ 18{,}854 \text{ k-in.} \end{bmatrix}$$

8.15

$$\mathbf{d} = \begin{bmatrix} -0.06273 \text{ in.} \\ 0.03588 \text{ in.} \\ -0.1942 \text{ in.} \\ -0.4836 \text{ rad} \\ 0.001013 \text{ rad} \\ 0.3067 \text{ rad} \end{bmatrix}$$

$$\mathbf{R} = \begin{bmatrix} -3.818 \text{ k} \\ -5.406 \text{ k} \\ -6.013 \text{ k} \\ -600.5 \text{ k-in.} \\ -0.5053 \text{ k-in.} \\ 381.5 \text{ k-in.} \\ 11.81 \text{ k} \\ 5.968 \text{ k} \\ 0.01179 \text{ k} \\ 301.5 \text{ k-in.} \\ -2.204 \text{ k-in.} \\ 477.2 \text{ k-in.} \\ -7.996 \text{ k} \\ -0.562 \text{ k} \\ 6.001 \text{ k} \\ 193.9 \text{ k-in.} \\ -1.143 \text{ k-in.} \\ -215.9 \text{ k-in.} \end{bmatrix}$$

8.17

$$\mathbf{d} = \begin{bmatrix} -3.265 \text{ in.} \\ -0.01613 \text{ in.} \\ 0.3561 \text{ in.} \\ 0.001313 \text{ rad} \\ 0.01004 \text{ rad} \\ -0.001108 \text{ rad} \\ 3.266 \text{ in.} \\ -0.0151 \text{ in.} \\ 0.3548 \text{ in.} \\ -0.0001316 \text{ rad} \\ 0.01004 \text{ rad} \\ -0.002582 \text{ rad} \\ 3.271 \text{ in.} \\ -0.01613 \text{ in.} \\ -0.3561 \text{ in.} \\ -0.001313 \text{ rad} \\ 0.01006 \text{ rad} \\ 0.001105 \text{ rad} \\ -3.271 \text{ in.} \\ -0.0151 \text{ in.} \\ -0.3548 \text{ in.} \\ 0.0001316 \text{ rad} \\ 0.01006 \text{ rad} \\ 0.002585 \text{ rad} \end{bmatrix} \quad \mathbf{R} = \begin{bmatrix} 11.45 \text{ k} \\ 61.97 \text{ k} \\ -4.62 \text{ k} \\ -1{,}378 \text{ k-in.} \\ -5.934 \text{ k-in.} \\ -2{,}021 \text{ k-in.} \\ -9.255 \text{ k} \\ 58.03 \text{ k} \\ -14.6 \text{ k} \\ -2{,}572 \text{ k-in.} \\ -5.934 \text{ k-in.} \\ 1{,}758 \text{ k-in.} \\ -11.46 \text{ k} \\ 61.97 \text{ k} \\ 4.62 \text{ k} \\ 1{,}378 \text{ k-in.} \\ -5.947 \text{ k-in.} \\ 2{,}024 \text{ k-in.} \\ 9.271 \text{ k} \\ 58.03 \text{ k} \\ 14.6 \text{ k} \\ 2{,}572 \text{ k-in.} \\ -5.947 \text{ k-in.} \\ -1{,}761 \text{ k-in.} \end{bmatrix}$$

Chapter 9

9.1 $\quad \mathbf{d} = \begin{bmatrix} 0.063295 \\ -0.42908 \end{bmatrix}$ in.

$Q_{a1} = 30.593$ k (T); $\quad Q_{a2} = 122.96$ k (C);

$Q_{a3} = 24.343$ k (T)

$$\mathbf{R} = \begin{bmatrix} 73.777 \\ 98.369 \\ 6.816 \\ -23.369 \\ -30.593 \\ 0 \end{bmatrix} \text{k}$$

9.3 See answer to Problem 7.19.

9.11

$$FS_b = \frac{15W}{33}; \ FM_b = \frac{7WL}{66}; \ FS_e = \frac{18W}{33}; \ FM_e = -\frac{5WL}{33}$$

9.13 $d_1 = 6; \ d_2 = -11; \ d_3 = 9$

Chapter 10

10.1 (a) $\quad P \cong \left(\dfrac{2EA \sin^2\theta}{L} \right) \delta$

(b) $\quad P = 2EA \left[\sin\theta + \left(\dfrac{\delta}{L} \right) \right] \left[\dfrac{\sqrt{1 + \left(\frac{\delta}{L} \right)^2 + 2\left(\frac{\delta}{L} \right) \sin\theta} - 1}{\sqrt{1 + \left(\frac{\delta}{L} \right)^2 + 2\left(\frac{\delta}{L} \right) \sin\theta}} \right]$

10.3 $\quad \mathbf{d} = \begin{bmatrix} -0.23233 \\ -1.0581 \end{bmatrix}$ m

$Q_{a1} = 1,827.2$ kN (C); $\quad Q_{a2} = 2,152.7$ kN (C);

$$\mathbf{R} = \begin{bmatrix} 1,624.2 \\ 837.11 \\ -1,624.2 \\ 1,412.9 \end{bmatrix} \text{kN}$$

10.5 $\quad \mathbf{d} = \begin{bmatrix} -0.040921 \\ 3.0647 \\ -3.3036 \end{bmatrix}$ m

$Q_{a1} = 859.34$ kN (C); $\quad Q_{a2} = 1,032.5$ kN (T);

$Q_{a3} = 1,122.5$ kN (C)

$$\mathbf{R} = \begin{bmatrix} -0.013871 \\ -572.3 \\ 722.27 \end{bmatrix} \text{kN}$$