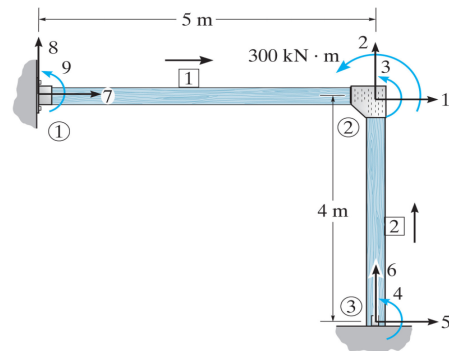


# Problem 16a-2



Element 1

$$\begin{aligned} L &= 5 \text{ m} \\ I &= 300 (10^6) \text{ mm}^4 \\ A &= 21 (10^3) \text{ mm}^2 \\ E &= 200 \text{ GPa} \\ \theta_x &= 0^\circ \\ \theta_y &= 90^\circ \end{aligned}$$

$$\begin{aligned} \lambda_x &= 1.000 \\ \lambda_y &= 0.000 \end{aligned}$$

$$\begin{aligned} AE/L &= 840,000 \text{ kN/m} \\ 12EI/L^3 &= 5,760 \text{ kN/m} \\ 6EI/L^2 &= 14,400 \text{ kN} \\ 4EI/L &= 48,000 \text{ kNm} \\ 2EI/L &= 24,000 \text{ kNm} \end{aligned}$$

| 7        | 8      | 9       | 1        | 2       | 3       |   |
|----------|--------|---------|----------|---------|---------|---|
| 840,000  | 0      | 0       | -840,000 | 0       | 0       | 7 |
| 0        | 5,760  | 14,400  | 0        | -5,760  | 14,400  | 8 |
| 0        | 14,400 | 48,000  | 0        | -14,400 | 24,000  | 9 |
| -840,000 | 0      | 0       | 840,000  | 0       | 0       | 1 |
| 0        | -5,760 | -14,400 | 0        | 5,760   | -14,400 | 2 |
| 0        | 14,400 | 24,000  | 0        | -14,400 | 48,000  | 3 |

Element 2

$$\begin{aligned} L &= 4 \text{ m} \\ I &= 300 (10^6) \text{ mm}^4 \\ A &= 21 (10^3) \text{ mm}^2 \\ E &= 200 \text{ GPa} \\ \theta_x &= 90^\circ \\ \theta_y &= 0^\circ \end{aligned}$$

$$\begin{aligned} \lambda_x &= 0.000 \\ \lambda_y &= 1.000 \end{aligned}$$

$$\begin{aligned} AE/L &= 1,050,000 \text{ kN/m} \\ 12EI/L^3 &= 11,250 \text{ kN/m} \\ 6EI/L^2 &= 22,500 \text{ kN} \\ 4EI/L &= 60,000 \text{ kNm} \\ 2EI/L &= 30,000 \text{ kNm} \end{aligned}$$

| 5       | 6          | 4       | 1       | 2          | 3       |   |
|---------|------------|---------|---------|------------|---------|---|
| 11,250  | 0          | -22,500 | -11,250 | 0          | -22,500 | 5 |
| 0       | 1,050,000  | 0       | 0       | -1,050,000 | 0       | 6 |
| -22,500 | 0          | 60,000  | 22,500  | 0          | 30,000  | 4 |
| -11,250 | 0          | 22,500  | 11,250  | 0          | 22,500  | 1 |
| 0       | -1,050,000 | 0       | 0       | 1,050,000  | 0       | 2 |
| -22,500 | 0          | 30,000  | 22,500  | 0          | 60,000  | 3 |

|    | 1        | 2       | 3       | 4 | 5 | 6 | 7        | 8      | 9       |   |
|----|----------|---------|---------|---|---|---|----------|--------|---------|---|
| k1 | 840,000  | 0       | 0       |   |   |   | -840,000 | 0      | 0       | 1 |
|    | 0        | 5,760   | -14,400 |   |   |   | 0        | -5,760 | -14,400 | 2 |
|    | 0        | -14,400 | 48,000  |   |   |   | 0        | 14,400 | 24,000  | 3 |
|    |          |         |         |   |   |   |          |        |         | 4 |
|    |          |         |         |   |   |   |          |        |         | 5 |
|    |          |         |         |   |   |   |          |        |         | 6 |
|    | -840,000 | 0       | 0       |   |   |   | 840,000  | 0      | 0       | 7 |
|    | 0        | -5,760  | 14,400  |   |   |   | 0        | 5,760  | 14,400  | 8 |
|    | 0        | -14,400 | 24,000  |   |   |   | 0        | 14,400 | 48,000  | 9 |

|    | 1       | 2          | 3       | 4       | 5       | 6          | 7 | 8 | 9 |   |
|----|---------|------------|---------|---------|---------|------------|---|---|---|---|
| k2 | 11,250  | 0          | 22,500  | 22,500  | -11,250 | 0          |   |   |   | 1 |
|    | 0       | 1,050,000  | 0       | 0       | 0       | -1,050,000 |   |   |   | 2 |
|    | 22,500  | 0          | 60,000  | 30,000  | -22,500 | 0          |   |   |   | 3 |
|    | 22,500  | 0          | 30,000  | 60,000  | -22,500 | 0          |   |   |   | 4 |
|    | -11,250 | 0          | -22,500 | -22,500 | 11,250  | 0          |   |   |   | 5 |
|    | 0       | -1,050,000 | 0       | 0       | 0       | 1,050,000  |   |   |   | 6 |
|    |         |            |         |         |         |            |   |   |   | 7 |
|    |         |            |         |         |         |            |   |   |   | 8 |
|    |         |            |         |         |         |            |   |   |   | 9 |

|   | 1        | 2          | 3       | 4       | 5       | 6          | 7        | 8      | 9       |   |
|---|----------|------------|---------|---------|---------|------------|----------|--------|---------|---|
| K | 851,250  | 0          | 22,500  | 22,500  | -11,250 | 0          | -840,000 | 0      | 0       | 1 |
|   | 0        | 1,055,760  | -14,400 | 0       | 0       | -1,050,000 | 0        | -5,760 | -14,400 | 2 |
|   | 22,500   | -14,400    | 108,000 | 30,000  | -22,500 | 0          | 0        | 14,400 | 24,000  | 3 |
|   | 22,500   | 0          | 30,000  | 60,000  | -22,500 | 0          | 0        | 0      | 0       | 4 |
|   | -11,250  | 0          | -22,500 | -22,500 | 11,250  | 0          | 0        | 0      | 0       | 5 |
|   | 0        | -1,050,000 | 0       | 0       | 0       | 1,050,000  | 0        | 0      | 0       | 6 |
|   | -840,000 | 0          | 0       | 0       | 0       | 0          | 840,000  | 0      | 0       | 7 |
|   | 0        | -5,760     | 14,400  | 0       | 0       | 0          | 0        | 5,760  | 14,400  | 8 |
|   | 0        | -14,400    | 24,000  | 0       | 0       | 0          | 0        | 14,400 | 48,000  | 9 |

|   | 1       | 2         | 3       | 4      |     |                       |
|---|---------|-----------|---------|--------|-----|-----------------------|
| K | 851,250 | 0         | 22,500  | 22,500 | Q   | D = K <sup>-1</sup> Q |
|   | 0       | 1,055,760 | -14,400 | 0      | 0   | -0.00004 m            |
|   | 22,500  | -14,400   | 108,000 | 30,000 | 0   | 0.00004 m             |
|   | 22,500  | 0         | 30,000  | 60,000 | 300 | 0.00324 radians       |
|   |         |           |         |        | 0   | -0.00160 m            |

K

| 1        | 2          | 3       | 4       | 5       | 6          | 7        | 8      | 9       |   |
|----------|------------|---------|---------|---------|------------|----------|--------|---------|---|
| 851,250  | 0          | 22,500  | 22,500  | -11,250 | 0          | -840,000 | 0      | 0       | 1 |
| 0        | 1,055,760  | -14,400 | 0       | 0       | -1,050,000 | 0        | -5,760 | -14,400 | 2 |
| 22,500   | -14,400    | 108,000 | 30,000  | -22,500 | 0          | 0        | 14,400 | 24,000  | 3 |
| 22,500   | 0          | 30,000  | 60,000  | -22,500 | 0          | 0        | 0      | 0       | 4 |
| -11,250  | 0          | -22,500 | -22,500 | 11,250  | 0          | 0        | 0      | 0       | 5 |
| 0        | -1,050,000 | 0       | 0       | 0       | 1,050,000  | 0        | 0      | 0       | 6 |
| -840,000 | 0          | 0       | 0       | 0       | 0          | 840,000  | 0      | 0       | 7 |
| 0        | -5,760     | 14,400  | 0       | 0       | 0          | 0        | 5,760  | 14,400  | 8 |
| 0        | -14,400    | 24,000  | 0       | 0       | 0          | 0        | 14,400 | 48,000  | 9 |

| D        | KD     |     |
|----------|--------|-----|
| -0.00004 | 0.00   | kN  |
| 0.00004  | 0.00   | kN  |
| 0.00324  | 300.00 | kNm |
| -0.00160 | 0.00   | kNm |
| 0        | -36.30 | kN  |
| 0        | -46.37 | kN  |
| 0        | 36.30  | kN  |
| 0        | 46.37  | kN  |
| 0        | 77.07  | kNm |

