global coordinates:

$$
[K]^e = \frac{2EI}{\mu_0 h^3}\begin{bmatrix}
\mu\cos^2\alpha + 6\sin^2\alpha & (\mu-6)\cos\alpha\sin\alpha & 3h\sin\alpha & -(\mu\cos^2\alpha + 6\sin^2\alpha) & -(\mu-6)\cos\alpha\sin\alpha & 3h\sin\alpha \\
(\mu-6)\cos\alpha\sin\alpha & \mu\sin^2\alpha + 6\cos^2\alpha & -3h\cos\alpha & -(\mu-6)\sin\alpha\cos\alpha & -(\mu\sin^2\alpha + 6\cos^2\alpha) & -3h\cos\alpha \\
3h\sin\alpha & -3h\cos\alpha & h^2(1.5+6\Lambda) & -3h\sin\alpha & 3h\cos\alpha & h^2(1.5-6\Lambda) \\
-(\mu\cos^2\alpha + 6\sin^2\alpha) & -(\mu-6)\sin\alpha\cos\alpha & -3h\sin\alpha & (\mu\cos^2\alpha + 6\sin^2\alpha) & (\mu-6)\cos\alpha\sin\alpha & -3h\sin\alpha \\
-(\mu-6)\cos\alpha\sin\alpha & -(\mu\sin^2\alpha + 6\cos^2\alpha) & 3h\cos\alpha & (\mu-6)\cos\alpha\sin\alpha & \mu\sin^2\alpha + 6\cos^2\alpha & 3h\cos\alpha \\
3h\sin\alpha & -3h\cos\alpha & h^2(1.5-6\Lambda) & -3h\sin\alpha & 3h\cos\alpha & h^2(1.5+6\Lambda)
\end{bmatrix} \tag{5.4.10a}
$$

$$
\{F\}^e = \begin{Bmatrix} F_1 \\ F_2 \\ F_3 \\ F_4 \\ F_5 \\ F_6 \end{Bmatrix}^e = \begin{Bmatrix} \bar F_1\cos\alpha - \bar F_2\sin\alpha \\ \bar F_1\sin\alpha + \bar F_2\cos\alpha \\ \bar F_3 \\ \bar F_4\cos\alpha - \bar F_5\sin\alpha \\ \bar F_4\sin\alpha + \bar F_5\cos\alpha \\ \bar F_6 \end{Bmatrix}^e \tag{5.4.10b}
$$

which is the element force vector referred to the global coordinates.

Example 5.4.1

The frame structure shown in Fig. 5.4.3 is to be analyzed for displacements and forces. Both members of the structure are made of the same material (E) and have the same geometric properties (A, I). The element stiffness matrices and force vectors in the global coordinate system (x, y, z) can be computed from (5.4.10a) and (5.4.10b). The geometric and material properties of each element are as follows (f is the axial and q is the transverse distributed load).

Element 1.

$$
L = 144\ \text{in.},\quad A = 10\ \text{in.}^2,\quad I = 10\ \text{in.}^{2}\,{}^{4},\quad \cos\alpha_1 = 0.0,\quad \sin\alpha_1 = -1.0
$$

$$
E = 10^6\ \text{psi},\quad f^{(1)} = 0,\quad q^{(1)} = \frac{P}{72}\ \text{lb/in.} \tag{5.4.11}
$$