In[∘]:=
```
k[AE_, EI_, L_] =
  {{AE/L, 0, 0, -AE/L, 0, 0}, {0, 12 (EI/L^3), 6 (EI/L^2), 0, -12 (EI/L^3), 6 (EI/L^2)},
   {0, 6 (EI/L^2), 4 (EI/L), 0, - 6 (EI/L^2), 2 (EI/L)}, {-AE/L, 0, 0, AE/L, 0, 0},
   {0, -12 (EI/L^3), -6 (EI/L^2), 0, 12 (EI/L^3), -6 (EI/L^2)},
   {0, 6 (EI/L^2), 2 EI/L, 0, -6 EI/L^2, 4 EI/L}};
MatrixForm[k[AE, EI, L]]
T[λx_, λy_] =
  {{λx, λy, 0, 0, 0, 0}, {-λy, λx, 0, 0, 0, 0}, {0, 0, 1, 0, 0, 0},
   {0, 0, 0, λx, λy, 0}, {0, 0, 0, -λy, λx, 0}, {0, 0, 0, 0, 0, 1}};
MatrixForm[T[λx, λy]]
```

Out[∘]//MatrixForm=

$$\begin{pmatrix} \frac{AE}{L} & 0 & 0 & -\frac{AE}{L} & 0 & 0 \\ 0 & \frac{12\,EI}{L^3} & \frac{6\,EI}{L^2} & 0 & -\frac{12\,EI}{L^3} & \frac{6\,EI}{L^2} \\ 0 & \frac{6\,EI}{L^2} & \frac{4\,EI}{L} & 0 & -\frac{6\,EI}{L^2} & \frac{2\,EI}{L} \\ -\frac{AE}{L} & 0 & 0 & \frac{AE}{L} & 0 & 0 \\ 0 & -\frac{12\,EI}{L^3} & -\frac{6\,EI}{L^2} & 0 & \frac{12\,EI}{L^3} & -\frac{6\,EI}{L^2} \\ 0 & \frac{6\,EI}{L^2} & \frac{2\,EI}{L} & 0 & -\frac{6\,EI}{L^2} & \frac{4\,EI}{L} \end{pmatrix}$$

Out[∘]//MatrixForm=

$$\begin{pmatrix} \lambda x & \lambda y & 0 & 0 & 0 & 0 \\ -\lambda y & \lambda x & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & \lambda x & \lambda y & 0 \\ 0 & 0 & 0 & -\lambda y & \lambda x & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

In[∘]:=
```
Vals = {AE → 0.015 × 200 × 10^9, EI -> 200 × 10^9 × 350 × 10^-6, L -> 4};
k1 = Transpose[T[1, 0]].k[AE, EI, L].T[1, 0] /. Vals;
k1 // MatrixForm
k2 = Transpose[T[0, -1]].k[AE, EI, L].T[0, -1] /. Vals;
k2 // MatrixForm
```

Out[∘]//MatrixForm=

$$\begin{pmatrix} 7.5\times10^{8} & 0 & 0 & -7.5\times10^{8} & 0 & 0 \\ 0 & 13\,125\,000 & 26\,250\,000 & 0 & -13\,125\,000 & 26\,250\,000 \\ 0 & 26\,250\,000 & 70\,000\,000 & 0 & -26\,250\,000 & 35\,000\,000 \\ -7.5\times10^{8} & 0 & 0 & 7.5\times10^{8} & 0 & 0 \\ 0 & -13\,125\,000 & -26\,250\,000 & 0 & 13\,125\,000 & -26\,250\,000 \\ 0 & 26\,250\,000 & 35\,000\,000 & 0 & -26\,250\,000 & 70\,000\,000 \end{pmatrix}$$

Out[∘]//MatrixForm=

$$\begin{pmatrix} 13\,125\,000 & 0 & 26\,250\,000 & -13\,125\,000 & 0 & 26\,250\,000 \\ 0 & 7.5\times10^{8} & 0 & 0 & -7.5\times10^{8} & 0 \\ 26\,250\,000 & 0 & 70\,000\,000 & -26\,250\,000 & 0 & 35\,000\,000 \\ -13\,125\,000 & 0 & -26\,250\,000 & 13\,125\,000 & 0 & -26\,250\,000 \\ 0 & -7.5\times10^{8} & 0 & 0 & 7.5\times10^{8} & 0 \\ 26\,250\,000 & 0 & 35\,000\,000 & -26\,250\,000 & 0 & 70\,000\,000 \end{pmatrix}$$

In[•]:=
```
k11 = IdentityMatrix[5] * 0
k11[[{1, 2, 3, 5}, {1, 2, 3, 5}]] =
  k11[[{1, 2, 3, 5}, {1, 2, 3, 5}]] + k1[[{4, 5, 6, 3}, {4, 5, 6, 3}]] ;
k11[[{1, 2, 3, 4}, {1, 2, 3, 4}]] =
  k11[[{1, 2, 3, 4}, {1, 2, 3, 4}]] + k2[[{1, 2, 3, 6}, {1, 2, 3, 6}]];
k11 // MatrixForm
```

Out[•]= {{0, 0, 0, 0, 0}, {0, 0, 0, 0, 0}, {0, 0, 0, 0, 0}, {0, 0, 0, 0, 0}, {0, 0, 0, 0, 0}}

Out[•]//MatrixForm=

$$\begin{pmatrix} 7.63125\times10^{8} & 0 & 26\,250\,000 & 26\,250\,000 & 0 \\ 0 & 7.63125\times10^{8} & -26\,250\,000 & 0 & -26\,250\,000 \\ 26\,250\,000 & -26\,250\,000 & 140\,000\,000 & 35\,000\,000 & 35\,000\,000 \\ 26\,250\,000 & 0 & 35\,000\,000 & 70\,000\,000 & 0 \\ 0 & -26\,250\,000 & 35\,000\,000 & 0 & 70\,000\,000 \end{pmatrix}$$

In[•]:=
```
k21 = ConstantArray[0, {4, 5}]
k21 [[{3, 4}, {1, 2, 3, 5}]] =
 k21 [[{3, 4}, {1, 2, 3, 5}]] + k1[[{1, 2}, {4, 5, 6, 3}]]
k21[[{1, 2}, {1, 2, 3, 4}]] = k21[[{1, 2}, {1, 2, 3, 4}]] + k2[[{4, 5}, {1, 2, 3, 6}]]
```

Out[•]= {{0, 0, 0, 0, 0}, {0, 0, 0, 0, 0}, {0, 0, 0, 0, 0}, {0, 0, 0, 0, 0}}

Out[•]= $\{\{-7.5\times10^{8}, 0, 0, 0\}, \{0, -13\,125\,000, 26\,250\,000, 26\,250\,000\}\}$

Out[•]= $\{\{-13\,125\,000, 0, -26\,250\,000, -26\,250\,000\}, \{0, -7.5\times10^{8}, 0, 0\}\}$

In[•]:=
```
Qk = {0, -41.25 × 10^3, 45 × 10^3, 0, 0};
Qk = {0, -30, 30, 0, -30} * 10^3;
Du = LinearSolve[k11, Qk] // FullSimplify;
% // MatrixForm
Qu = (k21.Du + {0, 0, 0, 30} * 10^3) 10^-3
```

Out[•]//MatrixForm=

$$\begin{pmatrix} -7.38021\times10^{-6} \\ -0.0000473802 \\ 0.000423571 \\ -0.000209018 \\ -0.000658125 \end{pmatrix}$$

Out[•]= {-5.53516, 35.5352, 5.53516, 24.4648}

```
{-5.535158680771621`, 35.53515868077162`,
 5.535158680771623`, 5.714841319228374`}
```

In[•]:=
```
k11 // MatrixForm
```

Out[•]//MatrixForm=

$$\begin{pmatrix} 4.79712\times10^{8} & 6.80192\times10^{8} & 0. & -2.18413\times10^{7} & 2.18413\times10^{7} \\ 6.80192\times10^{8} & 1.04654\times10^{9} & 0. & 1.45609\times10^{7} & -1.45609\times10^{7} \\ 0. & 0. & 140\,000\,000 & 35\,000\,000 & 35\,000\,000 \\ -2.18413\times10^{7} & 1.45609\times10^{7} & 35\,000\,000 & 70\,000\,000 & 0 \\ 2.18413\times10^{7} & -1.45609\times10^{7} & 35\,000\,000 & 0 & 70\,000\,000 \end{pmatrix}$$

```
Qk[[3]] / (6 EI/L /. Vals) // N
```

0.000428571

```
45 / 2. / 4.
```

```
5.625
```

Tutorial 6 problems

In[∘]:=
```
k[AE_, EI_, L_] =
  {{AE/L, 0, 0, -AE/L, 0, 0}, {0, 12 (EI/L^3), 6 (EI/L^2), 0, -12 (EI/L^3), 6 (EI/L^2)},
   {0, 6 (EI/L^2), 4 (EI/L), 0, - 6 (EI/L^2), 2 (EI/L)}, {-AE/L, 0, 0, AE/L, 0, 0},
   {0, -12 (EI/L^3), -6 (EI/L^2), 0, 12 (EI/L^3), -6 (EI/L^2)},
   {0, 6 (EI/L^2), 2 EI/L, 0, -6 EI/L^2, 4 EI/L}};
MatrixForm[k[AE, EI, L]]
T[λx_, λy_] =
  {{λx, λy, 0, 0, 0, 0}, {-λy, λx, 0, 0, 0, 0}, {0, 0, 1, 0, 0, 0},
   {0, 0, 0, λx, λy, 0}, {0, 0, 0, -λy, λx, 0}, {0, 0, 0, 0, 0, 1}};
ktruss[AE_, L_] := AE/L {{1, -1 }, {-1, 1}};
Ttruss[λx_, λy_] := {{λx, λy, 0, 0}, {0, 0, λx, λy}};
kbeam[EI_, L_] := {{12 EI/L^3, 6 EI/L^2, -12 EI/L^3, 6 EI/L^2}, {6 EI/L^2, 4 EI/L, -6 EI/L^2, 2 EI/L},
   {-12 EI/L^3, -6 EI/L^2, 12 EI/L^3, -6 EI/L^2}, {6 EI/L^2, 2 EI/L, -6 EI/L^2, 4 EI/L}};
```

Out[∘]//MatrixForm=

$$\begin{pmatrix} \frac{AE}{L} & 0 & 0 & -\frac{AE}{L} & 0 & 0 \\ 0 & \frac{12 EI}{L^3} & \frac{6 EI}{L^2} & 0 & -\frac{12 EI}{L^3} & \frac{6 EI}{L^2} \\ 0 & \frac{6 EI}{L^2} & \frac{4 EI}{L} & 0 & -\frac{6 EI}{L^2} & \frac{2 EI}{L} \\ -\frac{AE}{L} & 0 & 0 & \frac{AE}{L} & 0 & 0 \\ 0 & -\frac{12 EI}{L^3} & -\frac{6 EI}{L^2} & 0 & \frac{12 EI}{L^3} & -\frac{6 EI}{L^2} \\ 0 & \frac{6 EI}{L^2} & \frac{2 EI}{L} & 0 & -\frac{6 EI}{L^2} & \frac{4 EI}{L} \end{pmatrix}$$

Geometrical and Material properties of the truss and the beam

In[∘]:=
```
val = {AE → 100 × 10^5, L → Sqrt[4^2 + 6.^2]};
valb = {EI → 10^5 × 10^9 × 10^-6, L → 10};
λ1 = {4/Sqrt[4^2 + 6.^2], 6/Sqrt[4^2 + 6.^2]};
λ2 = {-4/Sqrt[4^2 + 6.^2], 6/Sqrt[4^2 + 6.^2]};
(* connectivity for near and far nodes *)
n1 = {6, 7, 1, 2};
n2 = {8, 9, 1, 2};
nb = {4, 5, 2, 3};

(* Initialise the stiffness matrix *)
K = ConstantArray[0, {10, 10}];
```

In[∘]:=
```
(* for beam *)
K[[nb, nb]] = K[[nb, nb]] + kbeam[EI, L] /. valb // N;

(* for truss member 1 *)
Transpose[Ttruss[λ1[[1]], λ1[[2]]]].
  ktruss[AE, L].Ttruss[λ1[[1]], λ1[[2]]] /. val
K[[n1, n1]] = K[[n1, n1]] + %;

(* for truss member 2 *)
Transpose[Ttruss[λ2[[1]], λ2[[2]]]].
  ktruss[AE, L].Ttruss[λ2[[1]], λ2[[2]]] /. val
K[[n2, n2]] = K[[n2, n2]] + %;
```

Out[∘]=
```
{{426 692., 640 039., -426 692., -640 039.},
 {640 039., 960 058., -640 039., -960 058.},
 {-426 692., -640 039., 426 692., 640 039.},
 {-640 039., -960 058., 640 039., 960 058.}}
```

Out[∘]=
```
{{426 692., -640 039., -426 692., 640 039.},
 {-640 039., 960 058., 640 039., -960 058.},
 {-426 692., 640 039., 426 692., -640 039.},
 {640 039., -960 058., -640 039., 960 058.}}
```

Following is the complete stiffness matrix

In[•]:=
```
MatrixForm[K]
```

Out[•]//MatrixForm=

853 385.	0.	0	0	0	-426 692.	-640 039.	-426 692.
0.	3.12012×10^6	$-6.\times10^6$	-1.2×10^6	$-6.\times10^6$	-640 039.	-960 058.	640 039.
0	$-6.\times10^6$	$4.\times10^7$	$6.\times10^6$	$2.\times10^7$	0	0	0
0	-1.2×10^6	$6.\times10^6$	1.2×10^6	$6.\times10^6$	0	0	0
0	$-6.\times10^6$	$2.\times10^7$	$6.\times10^6$	$4.\times10^7$	0	0	0
-426 692.	-640 039.	0	0	0	426 692.	640 039.	0
-640 039.	-960 058.	0	0	0	640 039.	960 058.	0
-426 692.	640 039.	0	0	0	0	0	426 692.
640 039.	-960 058.	0	0	0	0	0	-640 039.
0	0	0	0	0	0	0	0

The unknown displacements are: 2, 3. The known forces are:

In[•]:=
```
f = {-30 × 10^3, 0};
K[[{2, 3}, {2, 3}]];
du = LinearSolve[%, f]
```

Out[•]= {-0.0135128, -0.00202692}

Support reactions for the beam

In[•]:=
```
(kbeam[EI, L] /. valb).{0, 0, du[[1]], du[[2]]}
```

Out[•]= {4053.84, 40 538.4, -4053.84, 0.}

In[•]:=
```
λx = λ1[[1]];
λy = λ1[[2]];
AE/L {-λx, -λy, λx, λy}.{0, 0, 0, du[[1]]} /. val
```

Out[•]= -15 591.7

Problem 2

In[•]:=
```
kbeam[EI, L];
val1 = {EI → 10^5 × 10^9 × 10^-6, L → 2};
val2 = {EI → 10^5 × 10^9 × 10^-6, L → 3};
n1 = {1, 2, 3, 4};
n2 = {3, 4, 5, 6};
q10 = {15, 15 2^2/12, 15, -15 2^2/12} * 1000;
q20 = {200/9, 30 * 2^2/3^2, 70/9, -30 * 2/3^2} * 1000;
K = ConstantArray[0, {6, 6}];
q0 = ConstantArray[0, {6}];
K[[n1, n1]] = K[[n1, n1]] + kbeam[EI, L] /. val1;
K[[n2, n2]] = K[[n2, n2]] + kbeam[EI, L] /. val2;
q0[[n1]] = q0[[n1]] + q10;
q0[[n2]] = q0[[n2]] + q20;
```

```
In[•]:= MatrixForm[K]
        MatrixForm[10^-3 q0]
```

Out[•]//MatrixForm=

$$\begin{pmatrix} 150\,000\,000 & 150\,000\,000 & -150\,000\,000 & 150\,000\,000 & 0 & 0 \\ 150\,000\,000 & 200\,000\,000 & -150\,000\,000 & 100\,000\,000 & 0 & 0 \\ -150\,000\,000 & -150\,000\,000 & \frac{1\,750\,000\,000}{9} & -\frac{250\,000\,000}{3} & -\frac{400\,000\,000}{9} & \frac{200\,000\,000}{3} \\ 150\,000\,000 & 100\,000\,000 & -\frac{250\,000\,000}{3} & \frac{1\,000\,000\,000}{3} & -\frac{200\,000\,000}{3} & \frac{200\,000\,000}{3} \\ 0 & 0 & -\frac{400\,000\,000}{9} & -\frac{200\,000\,000}{3} & \frac{400\,000\,000}{9} & -\frac{200\,000\,000}{3} \\ 0 & 0 & \frac{200\,000\,000}{3} & \frac{200\,000\,000}{3} & -\frac{200\,000\,000}{3} & \frac{400\,000\,000}{3} \end{pmatrix}$$

Out[•]//MatrixForm=

$$\begin{pmatrix} 15 \\ 5 \\ \frac{335}{9} \\ \frac{25}{3} \\ \frac{70}{9} \\ -\frac{20}{3} \end{pmatrix}$$

```
In[•]:= Solve[K[[4, 4]] d4 + q0[[4]] == 0, d4] // N
        10^-3 (K[[{1, 2, 3, 5, 6}, 4]] * d4 + q0[[{1, 2, 3, 5, 6}]] /. %[[1]])

Out[•]= {{d4 → -0.000025}}

Out[•]= {11.25, 2.5, 39.3056, 9.44444, -8.33333}
```

Problem 3

```
In[•]:= λ1 = {1, 0};
        λ2 = {1, 0};
        λ3 = {0, 1};
        n1 = {1, 2, 3, 4, 5, 6};
        n2 = {4, 5, 6, 7, 8, 9};
        n3 = {10, 11, 12, 4, 5, 6};
        kp = k[AE, EI, L];
        k1 = Transpose[T[1, 0]].kp.T[1, 0];
        k2 = k1;
        k3 = Transpose[T[0, 1]].kp.T[0, 1];
```

Material properties

```
In[•]:= val = {EI → 10^5 × 10^9 × 10^-6, AE → 100 × 10^5, L → 2, W → 1000};
```

Assembling the matrix

```
In[•]:= K = ConstantArray[0, {12, 12}];
        K[[n1, n1]] = K[[n1, n1]] + k1;
        K[[n2, n2]] = K[[n2, n2]] + k2;
        K[[n3, n3]] = K[[n3, n3]] + k3;
```

Find the force vector

```
In[•]:= q10 = {0, W/2, W (L)/8, 0, W/2, - W (L)/8};
q20 = q10 * 0;
q30 = q30 * 0;
(* total force vector *)
q0 = ConstantArray[0, 12];
q0[[n1]] = q0[[n1]] + q10;
q0[[n2]] = q0[[n2]] + q20;
q0[[n3]] = q0[[n3]] + q30;
```

Finding the displacement

```
In[•]:= qk0 = q0[[{4, 5, 6}]];
k11 = K[[{4, 5, 6}, {4, 5, 6}]];
du = LinearSolve[k11, -qk0] /. val // N
```

Out[•]= $\{-5.10204\times10^{-7}, -1.63934\times10^{-6}, 5.44218\times10^{-7}\}$

Unknown reactions

```
In[•]:= K[[{1, 2, 3, 7, 8, 9, 10, 11, 12}, {4, 5, 6}]].du +
    q0[[{1, 2, 3, 7, 8, 9, 10, 11, 12}]] /. val // N
```

```
Out[•]= {2.55102, 827.534, 550.323, 2.55102,
 164.269, -191.48, -5.10204, 8.19672, -22.1088}
```

Problem 4

Material properties of the beam

```
In[•]:= val1 = {EI → 10^5 × 10^9 × 10^-6, L → 6};
val2 = {EI → 10^5 × 10^9 × 10^-6, L → 1.5};
val3 = {EI → 10^5 × 10^9 × 10^-6, L → 3.5};
```

Connectivity for the beam

```
In[•]:= n1 = {1, 2, 3, 4};
n2 = {3, 4, 5, 6};
n3 = {5, 7, 8, 9};
```

Stiffness matrix for each beam and the global stiffness matrix 9 × 9.

```
k1 = kbeam[EI, L] /. val1;
k2 = kbeam[EI, L] /. val2;
k3 = kbeam[EI, L] /. val3;
K = ConstantArray[0, {9, 9}];
```

Assembling the stiffness matrix.

```
In[•]:= K[[n1, n1]] = K[[n1, n1]] + k1;
K[[n2, n2]] = K[[n2, n2]] + k2;
K[[n3, n3]] = K[[n3, n3]] + k3;
```

Unknown forces, fixed end forces and unknown displacements

In[•]:=
```
P = 100 × 10^3;
q10 = {P/2, P 6/8, P/2, -P 6/8} /. val1;
q20 = {0, 0, 0, 0};
Q = 80 × 10^3;
(* Intermediate computations *)
Mcd = Q 2^2 × 1.5/(3.5)^2;
Mdc = - Q 2 × 1.5^2/(3.5)^2;
Mtot = Mcd + Mdc;
Vc = Mtot/(3.5) + Q * 2/3.5;
Vd = - Mtot/3.5 + Q 1.5/3.5;

q30 = {Vc, Mcd, Vd, Mdc};

(* global q0 matrix *)

q0 = ConstantArray[0, 9];
```

Global q_0 array

In[•]:=
```
q0[[n1]] = q0[[n1]] + q10;
q0[[n2]] = q0[[n2]] + q20;
q0[[n3]] = q0[[n3]] + q30;
```

Unknown displacements

In[•]:=
```
nu = {4, 5, 6, 7};
K11 = K[[nu, nu]];
qu0 = q0[[nu]];
du = LinearSolve[K11, -qu0]
```

Out[•]= $\{0.000380155, 0.00019781, 7.73282 \times 10^{-6}, -0.000427633\}$

Unknown reactions

In[•]:=
```
nqu = {1, 2, 3, 8, 9};
qu = (K[[nqu, nu]].du + q0[[nqu]]) 10^-3
```

Out[•]= {56.3359, 87.6718, 76.7683, 46.8958, -44.1353}

Problem 2: Tutorial 8

In[1]:=
```
k[AE_, EI_, L_] =
  {{AE/L, 0, 0, -AE/L, 0, 0}, {0, 12 (EI/L^3), 6 (EI/L^2), 0, -12 (EI/L^3), 6 (EI/L^2)},
   {0, 6 (EI/L^2), 4 (EI/L), 0, - 6 (EI/L^2), 2 (EI/L)}, {-AE/L, 0, 0, AE/L, 0, 0},
   {0, -12 (EI/L^3), -6 (EI/L^2), 0, 12 (EI/L^3), -6 (EI/L^2)},
   {0, 6 (EI/L^2), 2 EI/L, 0, -6 EI/L^2, 4 EI/L}};
MatrixForm[k[AE, EI, L]]
T[λx_, λy_] =
  {{λx, λy, 0, 0, 0, 0}, {-λy, λx, 0, 0, 0, 0}, {0, 0, 1, 0, 0, 0},
   {0, 0, 0, λx, λy, 0}, {0, 0, 0, -λy, λx, 0}, {0, 0, 0, 0, 0, 1}};
ktruss[AE_, L_] := AE/L {{1, -1 }, {-1, 1}};
Ttruss[λx_, λy_] := {{λx, λy, 0, 0}, {0, 0, λx, λy}};
kbeam[EI_, L_] := {{12 EI/L^3, 6 EI/L^2, -12 EI/L^3, 6 EI/L^2}, {6 EI/L^2, 4 EI/L, -6 EI/L^2, 2 EI/L},
   {-12 EI/L^3, -6 EI/L^2, 12 EI/L^3, -6 EI/L^2}, {6 EI/L^2, 2 EI/L, -6 EI/L^2, 4 EI/L}};
```

Out[2]//MatrixForm=

$$\begin{pmatrix} \frac{AE}{L} & 0 & 0 & -\frac{AE}{L} & 0 & 0 \\ 0 & \frac{12\,EI}{L^3} & \frac{6\,EI}{L^2} & 0 & -\frac{12\,EI}{L^3} & \frac{6\,EI}{L^2} \\ 0 & \frac{6\,EI}{L^2} & \frac{4\,EI}{L} & 0 & -\frac{6\,EI}{L^2} & \frac{2\,EI}{L} \\ -\frac{AE}{L} & 0 & 0 & \frac{AE}{L} & 0 & 0 \\ 0 & -\frac{12\,EI}{L^3} & -\frac{6\,EI}{L^2} & 0 & \frac{12\,EI}{L^3} & -\frac{6\,EI}{L^2} \\ 0 & \frac{6\,EI}{L^2} & \frac{2\,EI}{L} & 0 & -\frac{6\,EI}{L^2} & \frac{4\,EI}{L} \end{pmatrix}$$

In[195]:=
```
(* connectivity *)
n1 = {1, 2, 3, 4};
n2 = {3, 4, 5, 6};
n3 = {7, 3};

(* material properties and geometry *)
val1 = {EI → 200 × 500, L → 10};
val2 = {AE → 10000/3, L → 10};
(* member stiffness *)
k1 = kbeam[EI, L] /. val1;
k2 = kbeam[EI, L] /. val1;
k3 = ktruss[AE, L] /. val2;
(* assemble stiffness matrix *)
Kg = ConstantArray[0, {11, 11}];
Kg[[n1, n1]] = Kg[[n1, n1]] + k1;
Kg[[n2, n2]] = Kg[[n2, n2]] + k2;
Kg[[n3, n3]] = Kg[[n3, n3]] + k3;
```

Solving various parts of the problem

```
In[207]:= (* obtain unknown degrees of freedom *)
          nu = {1, 2, 3, 4, 6};
          k11 = Kg[[nu, nu]];
          Qk = {-20, 80, 0, 0, 0};
          Du = LinearSolve[k11, Qk] // N

Out[210]= {-0.488, 0.0417333, -0.144, 0.0237333, 0.00973333}

In[213]:= (* to find the support reactions *)
          nk = {5, 7};
          k21 = Kg[[nk, nu]].Du

Out[214]= {-28., 48.}
```