Calculate the x, y coordinates of the nodes :

In[1]:=
```
a = b = 2.0; nx = 7; ny = 5;
nodes = Flatten[Table[{x, y}, {y, -b/2, b/2, b/(ny - 1)}, {x, -a/2, a/2, a/(nx - 1)}], 1]
```

Out[2]=
```
{{-1., -1.}, {-0.666667, -1.}, {-0.333333, -1.}, {-5.55112×10^-17, -1.}, {0.333333, -1.}, {0.666667, -1.}, {1., -1.},
 {-1., -0.5}, {-0.666667, -0.5}, {-0.333333, -0.5}, {-5.55112×10^-17, -0.5}, {0.333333, -0.5}, {0.666667, -0.5},
 {1., -0.5}, {-1., 0.}, {-0.666667, 0.}, {-0.333333, 0.}, {-5.55112×10^-17, 0.}, {0.333333, 0.}, {0.666667, 0.},
 {1., 0.}, {-1., 0.5}, {-0.666667, 0.5}, {-0.333333, 0.5}, {-5.55112×10^-17, 0.5}, {0.333333, 0.5}, {0.666667, 0.5},
 {1., 0.5}, {-1., 1.}, {-0.666667, 1.}, {-0.333333, 1.}, {-5.55112×10^-17, 1.}, {0.333333, 1.}, {0.666667, 1.}, {1., 1.}}
```

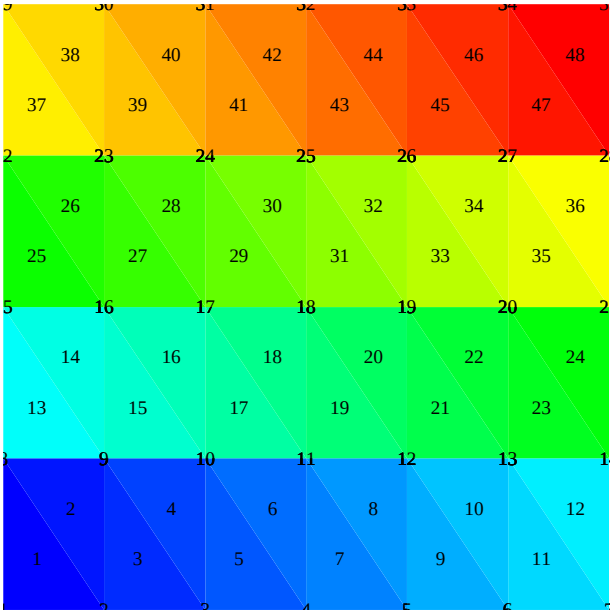
Calculate the indices of nodes of the triangle elements :

In[3]:=
```
elements = Flatten[Table[{{i, i + 1, i + nx}, {i + 1, i + nx + 1, i + nx}} + (j - 1) nx, {j, 1, ny - 1}, {i, 1, nx - 1}], 2]
```

Out[3]=
```
{{1, 2, 8}, {2, 9, 8}, {2, 3, 9}, {3, 10, 9}, {3, 4, 10}, {4, 11, 10}, {4, 5, 11}, {5, 12, 11}, {5, 6, 12},
 {6, 13, 12}, {6, 7, 13}, {7, 14, 13}, {8, 9, 15}, {9, 16, 15}, {9, 10, 16}, {10, 17, 16}, {10, 11, 17},
 {11, 18, 17}, {11, 12, 18}, {12, 19, 18}, {12, 13, 19}, {13, 20, 19}, {13, 14, 20}, {14, 21, 20},
 {15, 16, 22}, {16, 23, 22}, {16, 17, 23}, {17, 24, 23}, {17, 18, 24}, {18, 25, 24}, {18, 19, 25}, {19, 26, 25},
 {19, 20, 26}, {20, 27, 26}, {20, 21, 27}, {21, 28, 27}, {22, 23, 29}, {23, 30, 29}, {23, 24, 30}, {24, 31, 30},
 {24, 25, 31}, {25, 32, 31}, {25, 26, 32}, {26, 33, 32}, {26, 27, 33}, {27, 34, 33}, {27, 28, 34}, {28, 35, 34}}
```

Here is a picture to visualize the triangle elements :

In[4]:=
```
jmax = Length[elements]; $DefaultFont = {"Times-Roman", 9};
PlotColor[hue_] := Hue[2 (1 - Min[1, Max[0, hue]]) / 3];
Show[Graphics[Table[plist = Map[nodes[[#]] &, elements[[j]]];
      {PlotColor[(j - 1) / (jmax - 1)], Polygon[plist], RGBColor[0, 0, 0],
       Text[j, Plus @@ plist / 3], Table[Text[elements[[j, i]], plist[[i]], {i, 1, 3}]}, {j, 1, jmax, 1}]],
  AspectRatio → Automatic, PlotRange → {{-1, 1} a / 2, {-1, 1} b / 2}];
```



Calculate the local stiffness matrices :

In[6]:= **Klocal =**

$$\textbf{Map}\Big[\textbf{Module}\Big[\{\}, \textbf{Do}[\{\Delta x_i, \Delta y_i\} = \textbf{nodes}[\![\#[\![i]\!]]\!] - \textbf{nodes}[\![\#[\![1]\!]]\!], \{i, 2, 3\}];\ \lambda_2 = \Delta x_2^2 + \Delta y_2^2;\ \lambda_{23} = \Delta x_2\, \Delta y_2 + \Delta x_3\, \Delta y_3;\ \lambda_3 = \Delta x_3^2 + \Delta y_3^2;\ \frac{1}{\Delta x_2\, \Delta y_3 - \Delta x_3\, \Delta y_2} \begin{pmatrix} \lambda_2 - \lambda_3 - 2\,\lambda_{23} & \lambda_{23} - \lambda_3 & \lambda_{23} - \lambda_2 \\ \lambda_{23} - \lambda_3 & \lambda_3 & -\lambda_{23} \\ \lambda_{23} - \lambda_2 & -\lambda_{23} & \lambda_2 \end{pmatrix}\Big]\ \&, \textbf{elements}\Big];$$

Map[
MatrixForm,
Klocal]

Out[7]=

$$\left\{\begin{pmatrix} -0.833333 & -1.5 & -0.666667 \\ -1.5 & 1.5 & 0. \\ -0.666667 & 0. & 0.666667 \end{pmatrix}, \begin{pmatrix} 1.33333 & -3.16667 & -2.5 \\ -3.16667 & 2.16667 & 1. \\ -2.5 & 1. & 1.5 \end{pmatrix}, \begin{pmatrix} -0.833333 & -1.5 & -0.666667 \\ -1.5 & 1.5 & 0. \\ -0.666667 & 0. & 0.666667 \end{pmatrix},\right.$$

$$\begin{pmatrix} 1.33333 & -3.16667 & -2.5 \\ -3.16667 & 2.16667 & 1. \\ -2.5 & 1. & 1.5 \end{pmatrix}, \begin{pmatrix} -0.833333 & -1.5 & -0.666667 \\ -1.5 & 1.5 & 0. \\ -0.666667 & 0. & 0.666667 \end{pmatrix}, \begin{pmatrix} 1.33333 & -3.16667 & -2.5 \\ -3.16667 & 2.16667 & 1. \\ -2.5 & 1. & 1.5 \end{pmatrix},$$

$$\begin{pmatrix} -0.833333 & -1.5 & -0.666667 \\ -1.5 & 1.5 & 0. \\ -0.666667 & 0. & 0.666667 \end{pmatrix}, \begin{pmatrix} 1.33333 & -3.16667 & -2.5 \\ -3.16667 & 2.16667 & 1. \\ -2.5 & 1. & 1.5 \end{pmatrix}, \begin{pmatrix} -0.833333 & -1.5 & -0.666667 \\ -1.5 & 1.5 & 0. \\ -0.666667 & 0. & 0.666667 \end{pmatrix},$$

$$\begin{pmatrix} 1.33333 & -3.16667 & -2.5 \\ -3.16667 & 2.16667 & 1. \\ -2.5 & 1. & 1.5 \end{pmatrix}, \begin{pmatrix} -0.833333 & -1.5 & -0.666667 \\ -1.5 & 1.5 & 0. \\ -0.666667 & 0. & 0.666667 \end{pmatrix}, \begin{pmatrix} 1.33333 & -3.16667 & -2.5 \\ -3.16667 & 2.16667 & 1. \\ -2.5 & 1. & 1.5 \end{pmatrix},$$

$$\begin{pmatrix} -0.833333 & -1.5 & -0.666667 \\ -1.5 & 1.5 & 0. \\ -0.666667 & 0. & 0.666667 \end{pmatrix}, \begin{pmatrix} 1.33333 & -3.16667 & -2.5 \\ -3.16667 & 2.16667 & 1. \\ -2.5 & 1. & 1.5 \end{pmatrix}, \begin{pmatrix} -0.833333 & -1.5 & -0.666667 \\ -1.5 & 1.5 & 0. \\ -0.666667 & 0. & 0.666667 \end{pmatrix},$$

$$\begin{pmatrix} 1.33333 & -3.16667 & -2.5 \\ -3.16667 & 2.16667 & 1. \\ -2.5 & 1. & 1.5 \end{pmatrix}, \begin{pmatrix} -0.833333 & -1.5 & -0.666667 \\ -1.5 & 1.5 & 0. \\ -0.666667 & 0. & 0.666667 \end{pmatrix}, \begin{pmatrix} 1.33333 & -3.16667 & -2.5 \\ -3.16667 & 2.16667 & 1. \\ -2.5 & 1. & 1.5 \end{pmatrix},$$

$$\begin{pmatrix} -0.833333 & -1.5 & -0.666667 \\ -1.5 & 1.5 & 0. \\ -0.666667 & 0. & 0.666667 \end{pmatrix}, \begin{pmatrix} 1.33333 & -3.16667 & -2.5 \\ -3.16667 & 2.16667 & 1. \\ -2.5 & 1. & 1.5 \end{pmatrix}, \begin{pmatrix} -0.833333 & -1.5 & -0.666667 \\ -1.5 & 1.5 & 0. \\ -0.666667 & 0. & 0.666667 \end{pmatrix},$$

$$\begin{pmatrix} 1.33333 & -3.16667 & -2.5 \\ -3.16667 & 2.16667 & 1. \\ -2.5 & 1. & 1.5 \end{pmatrix}, \begin{pmatrix} -0.833333 & -1.5 & -0.666667 \\ -1.5 & 1.5 & 0. \\ -0.666667 & 0. & 0.666667 \end{pmatrix}, \begin{pmatrix} 1.33333 & -3.16667 & -2.5 \\ -3.16667 & 2.16667 & 1. \\ -2.5 & 1. & 1.5 \end{pmatrix},$$

$$\begin{pmatrix} -0.833333 & -1.5 & -0.666667 \\ -1.5 & 1.5 & 0. \\ -0.666667 & 0. & 0.666667 \end{pmatrix}, \begin{pmatrix} 1.33333 & -3.16667 & -2.5 \\ -3.16667 & 2.16667 & 1. \\ -2.5 & 1. & 1.5 \end{pmatrix}, \begin{pmatrix} -0.833333 & -1.5 & -0.666667 \\ -1.5 & 1.5 & 0. \\ -0.666667 & 0. & 0.666667 \end{pmatrix},$$

$$\begin{pmatrix} 1.33333 & -3.16667 & -2.5 \\ -3.16667 & 2.16667 & 1. \\ -2.5 & 1. & 1.5 \end{pmatrix}, \begin{pmatrix} -0.833333 & -1.5 & -0.666667 \\ -1.5 & 1.5 & 0. \\ -0.666667 & 0. & 0.666667 \end{pmatrix}, \begin{pmatrix} 1.33333 & -3.16667 & -2.5 \\ -3.16667 & 2.16667 & 1. \\ -2.5 & 1. & 1.5 \end{pmatrix},$$

$$\begin{pmatrix} -0.833333 & -1.5 & -0.666667 \\ -1.5 & 1.5 & 0. \\ -0.666667 & 0. & 0.666667 \end{pmatrix}, \begin{pmatrix} 1.33333 & -3.16667 & -2.5 \\ -3.16667 & 2.16667 & 1. \\ -2.5 & 1. & 1.5 \end{pmatrix}, \begin{pmatrix} -0.833333 & -1.5 & -0.666667 \\ -1.5 & 1.5 & 0. \\ -0.666667 & 0. & 0.666667 \end{pmatrix},$$

$$\begin{pmatrix} 1.33333 & -3.16667 & -2.5 \\ -3.16667 & 2.16667 & 1. \\ -2.5 & 1. & 1.5 \end{pmatrix}, \begin{pmatrix} -0.833333 & -1.5 & -0.666667 \\ -1.5 & 1.5 & 0. \\ -0.666667 & 0. & 0.666667 \end{pmatrix}, \begin{pmatrix} 1.33333 & -3.16667 & -2.5 \\ -3.16667 & 2.16667 & 1. \\ -2.5 & 1. & 1.5 \end{pmatrix},$$

$$\left\{\begin{pmatrix} -0.833333 & -1.5 & -0.666667 \\ -1.5 & 1.5 & 0. \\ -0.666667 & 0. & 0.666667 \end{pmatrix}, \begin{pmatrix} 1.33333 & -3.16667 & -2.5 \\ -3.16667 & 2.16667 & 1. \\ -2.5 & 1. & 1.5 \end{pmatrix}, \begin{pmatrix} -0.833333 & -1.5 & -0.666667 \\ -1.5 & 1.5 & 0. \\ -0.666667 & 0. & 0.666667 \end{pmatrix},\right.$$

$$\begin{pmatrix} 1.33333 & -3.16667 & -2.5 \\ -3.16667 & 2.16667 & 1. \\ -2.5 & 1. & 1.5 \end{pmatrix}, \begin{pmatrix} -0.833333 & -1.5 & -0.666667 \\ -1.5 & 1.5 & 0. \\ -0.666667 & 0. & 0.666667 \end{pmatrix}, \begin{pmatrix} 1.33333 & -3.16667 & -2.5 \\ -3.16667 & 2.16667 & 1. \\ -2.5 & 1. & 1.5 \end{pmatrix},$$

$$\begin{pmatrix} -0.833333 & -1.5 & -0.666667 \\ -1.5 & 1.5 & 0. \\ -0.666667 & 0. & 0.666667 \end{pmatrix}, \begin{pmatrix} 1.33333 & -3.16667 & -2.5 \\ -3.16667 & 2.16667 & 1. \\ -2.5 & 1. & 1.5 \end{pmatrix}, \begin{pmatrix} -0.833333 & -1.5 & -0.666667 \\ -1.5 & 1.5 & 0. \\ -0.666667 & 0. & 0.666667 \end{pmatrix},$$

$$\left.\begin{pmatrix} 1.33333 & -3.16667 & -2.5 \\ -3.16667 & 2.16667 & 1. \\ -2.5 & 1. & 1.5 \end{pmatrix}, \begin{pmatrix} -0.833333 & -1.5 & -0.666667 \\ -1.5 & 1.5 & 0. \\ -0.666667 & 0. & 0.666667 \end{pmatrix}, \begin{pmatrix} 1.33333 & -3.16667 & -2.5 \\ -3.16667 & 2.16667 & 1. \\ -2.5 & 1. & 1.5 \end{pmatrix}\right\}$$

Assemble global stiffness matrix :

In[8]:=
```
nxy = Length[nodes]; Kglobal = Table[0, {nxy}, {nxy}];
Do[element = elements⟦j⟧;
   Do[Kglobal⟦element⟦m⟧, element⟦n⟧⟧ += Klocal⟦j, m, n⟧, {m, 1, 3}, {n, 1, 3}], {j, 1, jmax}];
Kglobal // MatrixForm
```

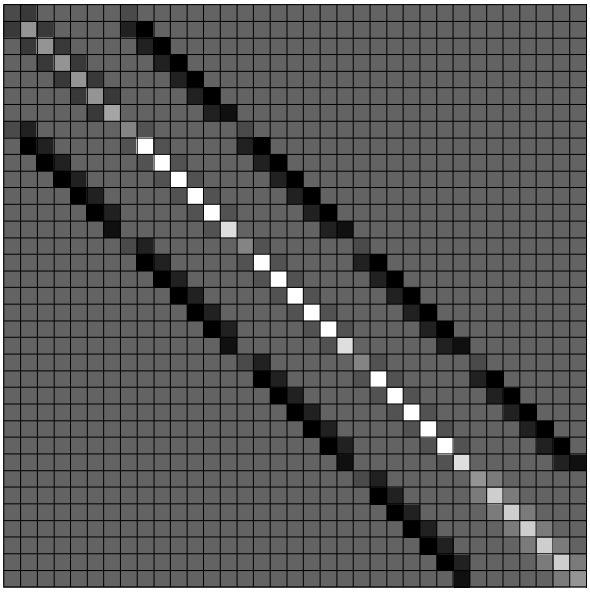
General::spell : Possible spelling error: new symbol name "element" is similar to existing symbols {Element, elements}. More…

Out[10]//MatrixForm=

−0.833333	−1.5	0	0	0	0	0	−0.666667	0	0
−1.5	2.	−1.5	0	0	0	0	−2.5	−3.83333	0
0	−1.5	2.	−1.5	0	0	0	0	−2.5	−3.83333
0	0	−1.5	2.	−1.5	0	0	0	0	−2.5
0	0	0	−1.5	2.	−1.5	0	0	0	0
0	0	0	0	−1.5	2.	−1.5	0	0	0
0	0	0	0	0	−1.5	2.83333	0	0	0
−0.666667	−2.5	0	0	0	0	0	1.33333	−0.5	0
0	−3.83333	−2.5	0	0	0	0	−0.5	6.33333	−0.5
0	0	−3.83333	−2.5	0	0	0	0	−0.5	6.33333
0	0	0	−3.83333	−2.5	0	0	0	0	−0.5
0	0	0	0	−3.83333	−2.5	0	0	0	0
0	0	0	0	0	−3.83333	−2.5	0	0	0
0	0	0	0	0	0	−3.16667	0	0	0
0	0	0	0	0	0	0	−0.666667	−2.5	0
0	0	0	0	0	0	0	0	−3.83333	−2.5
0	0	0	0	0	0	0	0	0	−3.83333
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	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
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	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
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	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
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	0	0	0	0	0

Here is a plot showing the bands of the global stiffness matrix :

In[11]:= **ListDensityPlot[Reverse[Kglobal], Frame → False];**



I' m assuming some constant values for p here :

In[12]:= **p = Table[1, {nxy}]; q = Inverse[Kglobal].p; Partition[q, nx] // MatrixForm**

Out[12]//MatrixForm=

$$\begin{pmatrix} -0.056987 & -0.428067 & 0.508466 & 0.336369 & -0.608219 & -0.108134 & 0.445014 \\ -0.465616 & -0.357212 & 0.273263 & -0.224554 & -0.521062 & 0.0863987 & 0.065393 \\ -0.501084 & -0.402704 & -0.198712 & -0.40966 & -0.157824 & -0.137853 & -0.562362 \\ -0.394978 & -0.398339 & -0.350245 & -0.0983963 & 0.0786792 & -0.575048 & -0.793372 \\ 0.0200245 & -0.302551 & -0.111546 & 0.19732 & 0.0760035 & -0.662684 & -0.392151 \end{pmatrix}$$