

```
In [7]: from sympy import init_printing, Matrix
init_printing()
```

```
In [8]: a = Matrix([1, 1, 0, 0])
b = Matrix([0, 1, 1, 0])
c = Matrix([0, 0, 1, 1])
a,b,c
```

```
Out[8]:  $\left( \begin{bmatrix} 1 \\ 1 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 0 \\ 1 \\ 1 \\ 0 \end{bmatrix}, \begin{bmatrix} 0 \\ 0 \\ 1 \\ 1 \end{bmatrix} \right)$ 
```

```
In [9]: A = Matrix.hstack(a, b, c, a - b, b - c, a - c)
A
```

```
Out[9]:  $\begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 \\ 1 & 1 & 0 & 0 & 1 & 1 \\ 0 & 1 & 1 & -1 & 0 & -1 \\ 0 & 0 & 1 & 0 & -1 & -1 \end{bmatrix}$ 
```

```
In [10]: A.LUdecomposition()
```

```
Out[10]:  $\left( \begin{bmatrix} 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 \\ 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 \end{bmatrix}, \begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & -1 & 1 & 0 \\ 0 & 0 & 1 & 0 & -1 & -1 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}, [] \right)$ 
```

```
In [11]: C=A.columnspace()
C
```

```
Out[11]:  $\left[ \begin{bmatrix} 1 \\ 1 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 0 \\ 1 \\ 1 \\ 0 \end{bmatrix}, \begin{bmatrix} 0 \\ 0 \\ 1 \\ 1 \end{bmatrix} \right]$ 
```

```
In [12]: A.transpose().nullspace()
```

```
Out[12]:  $\left[ \begin{bmatrix} -1 \\ 1 \\ -1 \\ 1 \end{bmatrix} \right]$ 
```

```
In [13]: R=A.rowspace()
R
```

```
Out[13]: [[1 0 0 1 0 1], [0 1 0 -1 1 0], [0 0 1 0 -1 -1]]
```

```
In [14]: A.nullspace()
```

Out[14]:
$$\begin{bmatrix} \begin{bmatrix} -1 \\ 1 \\ 0 \\ 1 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 0 \\ -1 \\ 1 \\ 0 \\ 1 \\ 0 \end{bmatrix}, \begin{bmatrix} -1 \\ 0 \\ 1 \\ 0 \\ 0 \\ 1 \end{bmatrix} \end{bmatrix}$$

In [15]: `Matrix.hstack(*C) * Matrix(R)`

Out[15]:
$$\begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 \\ 1 & 1 & 0 & 0 & 1 & 1 \\ 0 & 1 & 1 & -1 & 0 & -1 \\ 0 & 0 & 1 & 0 & -1 & -1 \end{bmatrix}$$

In [16]: `A.QRdecomposition()`

Out[16]:
$$\left(\begin{bmatrix} \frac{\sqrt{2}}{2} & -\frac{\sqrt{6}}{6} & \frac{\sqrt{3}}{6} \\ \frac{\sqrt{2}}{2} & \frac{\sqrt{6}}{6} & -\frac{\sqrt{3}}{6} \\ 0 & \frac{\sqrt{6}}{3} & \frac{\sqrt{3}}{6} \\ 0 & 0 & \frac{\sqrt{3}}{2} \end{bmatrix}, \begin{bmatrix} \sqrt{2} & \frac{\sqrt{2}}{2} & 0 & \frac{\sqrt{2}}{2} & \frac{\sqrt{2}}{2} & \sqrt{2} \\ 0 & \frac{\sqrt{6}}{2} & \frac{\sqrt{6}}{3} & -\frac{\sqrt{6}}{2} & \frac{\sqrt{6}}{6} & -\frac{\sqrt{6}}{3} \\ 0 & 0 & \frac{2\sqrt{3}}{3} & 0 & -\frac{2\sqrt{3}}{3} & -\frac{2\sqrt{3}}{3} \end{bmatrix} \right)$$

In []: