EG $y'' = 2y' + y$

Write this 2nd-order DE as a system of 1st-order DEs.

write $\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} y \\ y' \end{bmatrix}$ $\quad y_1' = y_2$, $\; y_2' = 2y_2 + y_1$

matrix form: $\vec{y}' = \begin{bmatrix} 0 & 1 \\ 1 & 2 \end{bmatrix} \vec{y}$

EG $y''' = 3y'' - 2y' + y$ 3rd order DE

as 1st order system

$\vec{y} = \begin{bmatrix} y \\ y' \\ y'' \end{bmatrix}$ $\quad \vec{y}' = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & -2 & 3 \end{bmatrix} \vec{y}$

$y_1' = y_2$

$y_2' = y_3$

$y_3' = 3y_3 - 2y_2 + y_1$