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1. We can make the filter into a  $4 \times 9$  weight matrix, with 0s where the image would not be filtered. The image matrix can be changed into a vector, and the dot product would be the feature map:

$$\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix} \xrightarrow{x} \begin{bmatrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \end{bmatrix} \xrightarrow{\text{W}} \begin{bmatrix} 1 & 3 & 0 & -1 & 2 & 0 & 0 & 0 & 0 \\ 0 & 1 & 3 & 0 & -1 & 2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 3 & 0 & -1 & 2 & 0 \\ 0 & 0 & 0 & 0 & 1 & 3 & 0 & -1 & 2 \end{bmatrix}$$

$$h = W \cdot \vec{x}$$