

Q1A)

Given 1D convolution mask  
 $(w_0, w_1, \dots, w_6)$

consider 1D matrix as  $\begin{bmatrix} a_1 \\ a_2 \\ \vdots \\ a_n \end{bmatrix}$

If we apply convolution mask  $(w_0, w_1, \dots, w_6)$  on  $f$   
 we need to reverse (i.e. rotate by  $180^\circ$ ) convolution mask and  
 pad with  $f-1$  zero to 1D matrix

We will get

$$\underbrace{(w_0 a_1, w_1 a_1 + w_0 a_2, \dots, w_6 a_n)}_{n+f-1 \text{ values (} f=7 \rightarrow \text{filter size)}}$$

We can represent it as product of these matrices

$$A = \begin{bmatrix} w_0 & 0 & 0 & \dots & 0 \\ w_1 & w_1 & 0 & \dots & 0 \\ w_2 & w_2 & w_1 & \dots & 0 \\ w_6 & w_3 & w_2 & \dots & 0 \\ 0 & w_6 & \vdots & \dots & 0 \\ \vdots & \vdots & \vdots & \dots & \vdots \\ 0 & \vdots & \vdots & \dots & \vdots \end{bmatrix}_{(n+f-1) \times n} \text{ (let)} \begin{bmatrix} a_1 \\ a_2 \\ \vdots \\ a_n \end{bmatrix}_{n \times 1}$$

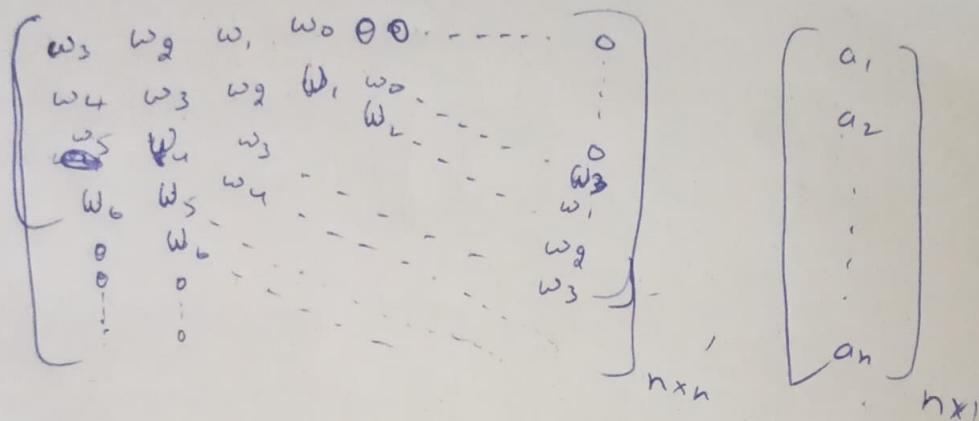
We know that we need to cut  $\frac{f-1}{2}$  values from start and  
 end of result, so we will get

$$\left[ w_3 a_1 + w_4 a_2 + w_5 a_3 + w_6 a_4 + \dots \right]$$

We can get this by removing 3 rows from top and three  
 rows from bottom from the above matrix (A)

1.e

we will get our final convolution as multiplication of



Properties of this matrix are all the diagonals contains same values and only there are 7 non-zero diagonals (diagonals containing non-zero value).

→ A potential application of such a matrix-based construction will be in efficient implementation of convolutional neural networks (CNN) and structured way of matrix representation helps in optimizing and regularizing filters during tasks like deconvolution and image reconstruction.