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Problem 1

(a)
Let X be a N- dimensional vector and W is a k-dimensional kernel. We want to convolve X with K and get a output Y.

$$X_{out} = X_{in} \bigodot W$$

In the forward pass, the i-th pixel of the output vector is given by the formula

$$X_{out}^{i} = \sum_{m=0}^{k-1} X_{in}^{i-\frac{k-1}{2}+m} W^{m}$$

(b)
For the back propagation, we will utilize the chain rule

$$\frac{\partial C}{\partial x_{in}} = \frac{\partial C}{\partial x_{out}} \frac{\partial x_{out}}{\partial x_{in}}$$