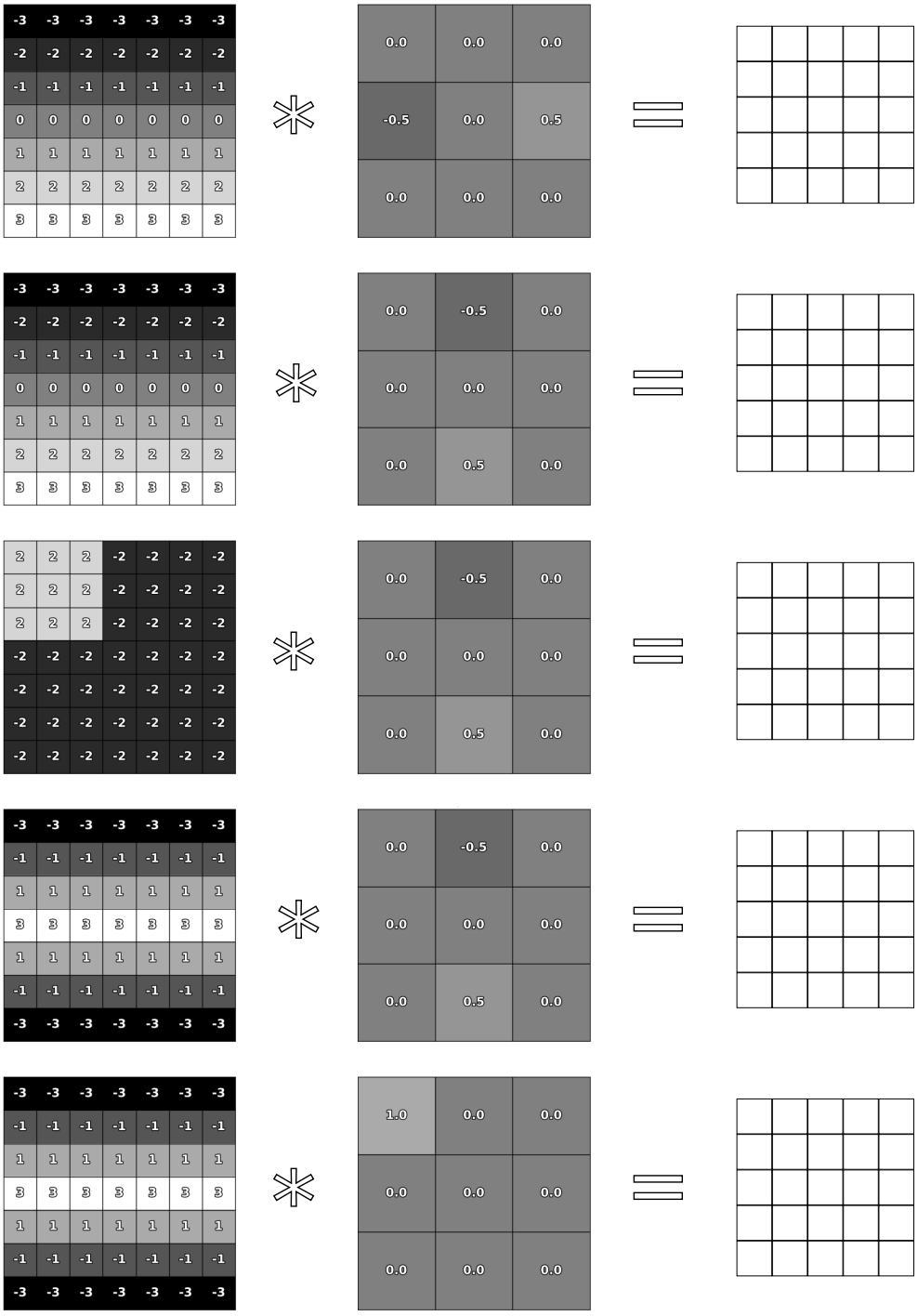
# Exercise Sheet 4

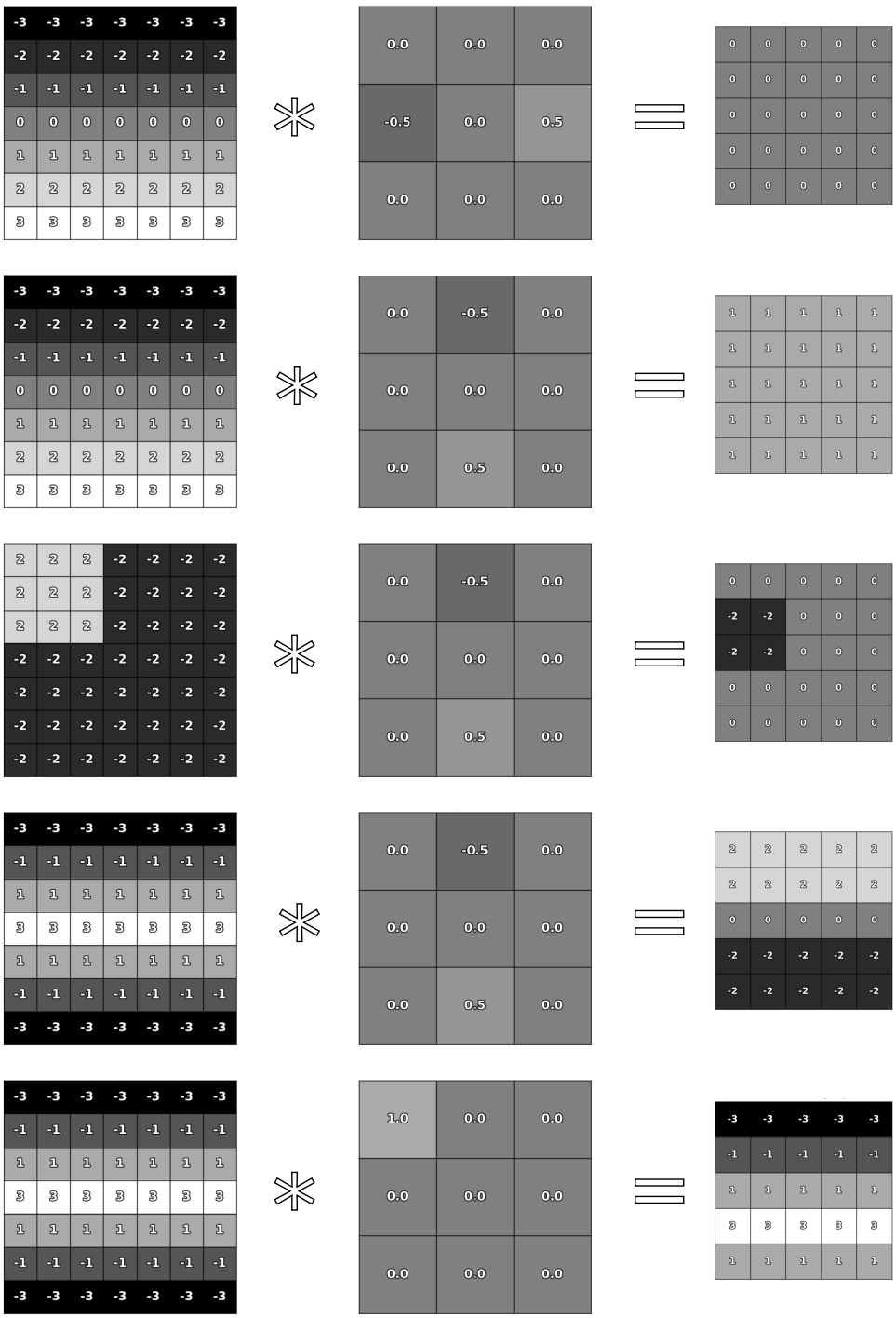
Neural Computation
University of Birmingham

Week 3 2025

**Exercise 1.** Consider the following input maps (left) and kernels (centre). Fill in the results of the convolution between the two in the grid on the right. Assume that the convolution is the '*computer science version*' without flipping (without negative sign in the indexation) and that there is no padding.



*Solution:*



**Exercise 2.** Answer the following questions related to convolutional neural networks (CNNs) with **justifications**.

1. Below, we define an image, a kernel, and the resulting feature map obtained by convolving the image with the kernel, with padding set to 1 and a stride of 1. Fill in the missing entries in the feature map.

2. We apply N convolutional kernels of size (H1, W1, D1) with stride=1 and padding = 0 to

Image

| | | | | |
|---|---|---|---|---|
| 2 | 3 | 2 | 4 | 5 |
| 4 | 1 | 2 | 5 | 2 |
| 4 | 1 | 1 | 2 | 5 |
| 2 | 8 | 8 | 7 | 3 |
| 1 | 2 | 2 | 2 | 1 |

Kernel

| | | |
|---|---|---|
| -1 | -1 | -1 |
| -1 | 8 | -1 |
| -1 | -1 | -1 |

Convolution Result

| | | | | |
|---|---|---|---|---|
| | 13 | 1 | 16 | 29 |
| 21 | -11 | -3 | | -5 |
| 16 | -22 | -26 | -17 | 21 |
| 0 | 43 | 39 | 32 | 7 |
| -4 | -5 | | -5 | -4 |

a 11 by 11 colour image (which has three channels). This results in a 5 by 5 feature map, with 1 channel. Please identify the values for (N, H1, W1, D1).

3. We apply 10 convolutional kernels, each sized 5 by 5, with a stride of 1 and padding of 2, to a 32 by 32 colour image (which has three channels). Please calculate the number of trainable parameters in this convolutional operation. Note: Please consider both the weights and biases.

*Solution:*

Image

| | | | | |
|---|---|---|---|---|
| 2 | 3 | 2 | 4 | 5 |
| 4 | 1 | 2 | 5 | 2 |
| 4 | 1 | 1 | 2 | 5 |
| 2 | 8 | 8 | 7 | 3 |
| 1 | 2 | 2 | 2 | 1 |

Kernel

| | | |
|---|---|---|
| -1 | -1 | -1 |
| -1 | 8 | -1 |
| -1 | -1 | -1 |

Convolution Result

| | | | | |
|---|---|---|---|---|
| 8 | 13 | 1 | 16 | 29 |
| 21 | -11 | -3 | 17 | -5 |
| 16 | -22 | -26 | -17 | 21 |
| 0 | 43 | 39 | 32 | 7 |
| -4 | -5 | -11 | -5 | -4 |

1.

2. N = 1, H1 = 7, W1 = 7, D1 = 3.

   D1 is the number of channels in the input (3).

   W1 and H1 have to be 7 so that the magic formula fits.

   W2 = 5 = 11-7+1 (see magic formula).

   N has to be 1, because there is only one output channel.

3. For each kernel, the total number of parameters is: Total parameters = Weights+Biases = (5×5×3)+1=76.

   Since we have 10 kernels, the total number of parameters for all kernels is: Total parameters=10×76=760.