# Week 7 Exercise Sheet

The following exercises have different levels of difficulty indicated by (\*), (\*\*), (\*\*\*).
An exercise with (\*) is a simple exercise requiring less time or effort to solve compared
to an exercise with (\*\*\*), which is a more complex exercise.

## Neural Networks

1. (\*\*) Consider a network with 1 hidden layer which can be described by the following
   equations:

$$\mathbf{h} = f\left(W^{(1)}\mathbf{x} + \mathbf{b}^{(1)}\right), \tag{1}$$

$$\mathbf{y} = f\left(W^{(2)}\mathbf{h} + \mathbf{b}^{(2)}\right), \tag{2}$$

   where $W^{(1)}$ and $W^{(2)}$ are matrices. If the activation function is linear $(f(a) = a)$,
   show that this is equivalent to a single layer $\mathbf{y} = W\mathbf{x} + \mathbf{b}$. Give expressions for $W$
   and $\mathbf{b}$ in terms of $W^{(1)}$, $W^{(2)}$, $\mathbf{b}^{(1)}$ and $\mathbf{b}^{(2)}$.

2. (\*) Consider the following input image:

$$x = \begin{bmatrix} 1 & 1 & 1 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 0 & 0 \end{bmatrix} \tag{3}$$

   If the convolutional filter is

$$W = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}, \tag{4}$$

   calculate the corresponding $3 \times 3$ output feature map. What feature does this filter
   detect?

3. (\*\*\*) If we have a $512 \times 512$ RGB colour image that we apply $100$ $5 \times 5$ filters with
   a stride of 7 and a padding of 2. What is the output volume size and how many
   parameters are in this layer?