

# Tutorial 10:

## Neural Networks

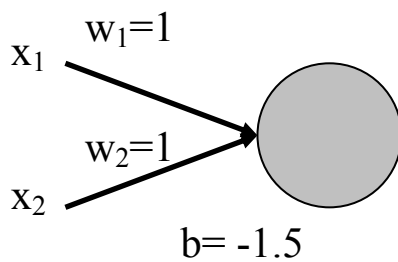
Name	Student no.

For this tutorial, you can discuss the questions in small groups (up to 4 students). Individually submit the answers to each of the 5 Questions.

### Question 1

Using the threshold function, the neural network below implements the logical-AND-function

$(a \wedge b)$ :



a) Come up with different weight and bias values that implement the same logical function.

b) Come up with a three-input network that implements the following logical function:

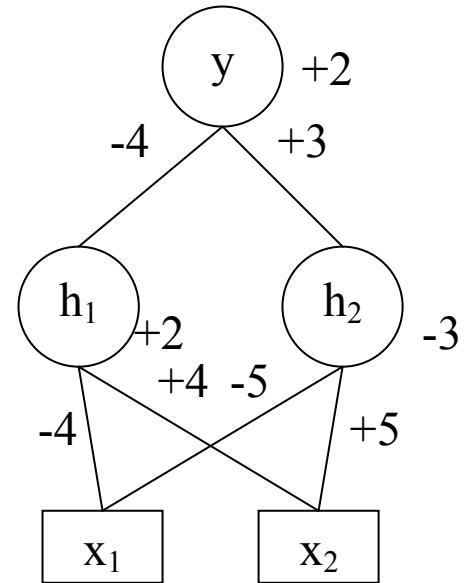
$a \wedge b \wedge (\neg c)$  (Note:  $\neg$  means NOT)

## Question 2

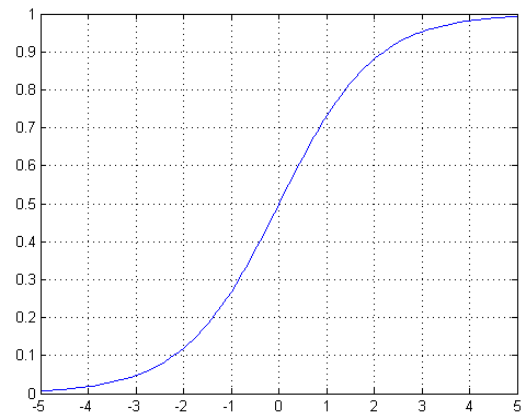
The multi-layer network on the right uses the logistic output function (see below).

Determine the hidden activations ( $h_1, h_2$ ), output ( $y$ ), and class ( $c$ ) for the following input patterns. Assume that the output is treated as Class A if  $y < 0.5$  and Class B if  $y \geq 0.5$ .

	Inputs		Hidden		Output	Class
	x1	x2	h1	h2	y	c
1	0	0				
2	0	1				
3	1	0				
4	1	1				



The logistic function:  $f(u) = \frac{1}{1 + e^{-u}}$



## Question 3

Neural networks with a single layer of weights (no hidden units) are useful for a variety of classification tasks. What tasks are multi-layer networks (2+ layers of weights: some hidden units) necessary for? In other words, what is fundamentally different about a multi-layer neural network?

### Question 4

Come up with a three-input multi-layer network that implements the following truth table:

Inputs				Output
	X1	X2	X3	Y
1	0	0	0	0
2	0	0	1	1
3	0	1	0	1
4	0	1	1	0
5	1	0	0	1
6	1	0	1	0
7	1	1	0	0
8	1	1	1	0

### Question 5

Describe backpropagation as used in multi-layer neural networks (equations not required)