

UNIVERSITY OF LONDON  
(University College London)

B.Sc. degree 2012

NEUR3041: Neural Computation: Models of Brain Function

DATE

Answer THREE questions.

1. What are supervised and unsupervised learning algorithms and how do they differ (3 marks)? Describe the perceptron learning algorithm and how it can be used to perform pattern recognition (5 marks). What limits the computational power of this algorithm, and how could it be improved (5 marks)? Discuss the biological plausibility of the learning algorithms employed by artificial neural networks (7 marks).

2. Describe how the competitive learning algorithm works and how it can be modified to model the development of topographical representations in the brain (6 marks). Describe the spatial firing patterns of 'place cells,' 'head-direction cells' and 'grid cells' recorded in freely moving rats (6 marks). Discuss the computational mechanisms which might enable place cells to encode specific environmental locations (8 marks).

3. Discuss the simplifications made by standard artificial neural network models of neuronal and synaptic function (5 marks). How could a neuron act as a "coincidence-detector" (4 marks)? Describe how the timing of firing of neurons, rather than their firing rates, could be used by the brain, and discuss experimental evidence that this does happen (11 marks).

4. What are the 'credit assignment' and 'temporal credit assignment' problems (4 marks)? How can occasional reinforcement from the environment be used to enable learning of the behavioural responses which will maximise reinforcement (10 marks)? Discuss how such a reinforcement learning system might be implemented in the brain (6 marks).

5. Describe how 'associative' and 'auto-associative' models of memory work (6 marks)? Why does storing too many patterns impair performance and how can interference between stored patterns be minimised (3 marks)? How does retrieval of information in these models differ from the retrieval of information in a library (3 marks)? Describe how information might be stored rapidly in the hippocampus and consolidated more slowly in neocortex, and discuss the evidence for and against this possibility (8 marks).

6. How can the firing rates of several neurons with imprecise tuning be combined to form an accurate estimate of the behavioural variable, and what factors determine how well this works (6 marks)? Discuss how movements of a limb to a given position in space might be aided by processing in the spinal cord (7 marks). How might a sequence of items or actions be stored and reproduced in the correct order (7 marks)?

END OF PAPER.