UNIVERSITY OF LONDON
(University College London)

B.Sc. degree 2013

NEUR3041: Neural Computation: Models of Brain Function

DATE:

Answer THREE questions. 20 marks are available for each question.

1. How does Rosenblatt's Perceptron learn to distinguish between two types of stimuli (5 marks)? What limits its performance (3 marks)? Describe the error back-propagation learning algorithm (5 marks) and how it can enable the motor commands required to perform a specific movement to be learned via a "forward model" (7 marks).

2. Describe Hopfield's model of pattern classification using spike timing (7 marks). Discuss its potential advantages and disadvantages compared to the Perceptron (3 marks), and the relative biological plausibility of both types of network (4 marks). Describe how "convergent force field generators" in the spinal cord can help to control limb movement (6 marks).

3. Describe how the competitive learning algorithm works (5 marks). Describe how it has been used to model some aspects of the firing of "place cells," and discuss the successes and limitations of this model (5 marks). Describe the spatial firing patterns of "head-direction cells" and "grid cells" (4 marks) and discuss how they could perform a process of "path integration" (6 marks).

4. Describe how "reinforcement learning" uses an internal critic to solve the "temporal credit assignment problem" (10 marks). Discuss the evidence that dopamine neurons signal "reward prediction error" (5 marks). How might neural firing in lateral intra-parietal cortex be used in decision making (5 marks)?

5. Describe the process by which information might be stored in an autoassociative memory network and how it might be retrieved later (5 marks). Discuss how the anatomy of the hippocampus is consistent with a role as an autoassociative memory network (5 marks). Describe how "competitive queuing" allows a sequence of actions to be performed in the correct order (5 marks), and discuss evidence that competitive queuing happens in the brain (5 marks).

6. Discuss the simplifications made by standard artificial neural network models of neuronal and synaptic function (5 marks). Describe how a neuron could act as a "coincidence-detector" (3 marks) and situations in which it could either sum or divide its inputs (4 marks). Describe a model of the function of EITHER the prefrontal cortex OR the cerebellum (8 marks).

END OF PAPER.