Name: **Student ID number:**

Question 1

a. Give two general properties of tasks in which deep learning approaches are often effective, but other AI approaches are not. (1 point)

b. Give a specific example of a data source to which artificial DCNNs are applied, which has:
   i) 1 dimension
   ii) 2 dimensions
   iii) 3 dimensions (3 points)

c. i) Describe the ReLU thresholding operation commonly used in artificial DCNNs, in terms of its inputs and outputs (1 point)
   ii) What is the main theoretical motivation for including a thresholding operation (1 point)

d. i) Describe the (max) pooling operation commonly used in artificial DCNNs (1 point)
   ii) What is the main theoretical motivation for including a pooling operation (1 point)

e. i) Describe the normalisation operation commonly used in artificial DCNNs (1 point)
   ii) What is the main theoretical motivation for including a normalisation operation (1 point)

Name: **Student ID number:**

Question 2

a. How are different inputs to a biological neuron integrated to determine the neuron's firing rate? (3 points)

b. i) How does the sharing of connection weights differ between biological neural networks and most artificial DCNNs? (1 point)

   ii) Give three reasons why this difference occurs, considering the properties of both biological and artificial networks. (3 points)

c. i) Describe one spatial analysis of visual position information (i.e. a spatial filter) in the retina.

   ii)Describe one non-spatial analysis of visual feature information in the retina. (3 points total for both parts)

Name: **Student ID number:**

Question 3

d. Kay et al. (2008) built 'receptive field' models of the responses of each point in an fMRI scan (voxel) to natural images. This allowed them to determine which image was shown from the resulting brain activity. For each voxel, they summarise its response preference (tuning) using three parameters, which closely follow the image parameters that determine whether a neuron in V1 will respond. What are these three parameters? (3 points)

a. In Yamins and colleagues' paper "Performance-optimized hierarchical models predict neural responses in higher visual cortex", they test the performance of various models, biological neurons, and human observers on object recognition tasks of increasing complexity.
   i) How did they change task complexity? (1 point)
   ii) How did the object recognition performance of different models, different biological neurons and human observers change with task complexity? (4 points)

b. Why does a network that includes recurrent lateral or feedback connections require models to run over several time points/cycles? (2 points)