

THE OPEN UNIVERSITY OF SRI LANKA
 BSc (IT) DEGREE PROGRAMME – LEVEL 05
 FINAL EXAMINATION: SEMESTER 1: 2026/2027
 COU5300: ARTIFICIAL NEURAL NETWORKS
 DURATION: TWO HOURS (2 HOURS)



Date: 19.06.2026

Time: 09.30 am – 11.30 am

Answer **ONLY FOUR (04)** Questions.

Q1

- i. Explain the term *linear separability*. (4 marks)
- ii. Explain the following neural network representations,
 - a. Block diagram
 - b. Signal-flow graph
 - c. Architectural graph (6 marks)
- iii. A neural network-based stock market prediction system adjusts its' weights after processing each incoming market data sample.
 Identify the training approach used in this scenario and discuss two (02) advantages of that training approach. (5 Marks)
- iv. A manufacturing company uses the perceptron learning rule to classify products as defective (1) or non-defective (0) based on two measurements. (Activation function: Step activation function).

The perceptron parameters are:

$$w_1 = 0, w_2 = 0, b = 0, \text{ learning rate} = 1$$

Calculate the following terms for the product with these parameters:

$$x_1 = 1, x_2 = 0, t = 1$$

- a. Compute the net input and output of the perceptron. (2 marks)
- b. Calculate the error. (2 marks)
- c. Update the weights and bias. (3 marks)
- d. Explain how the weight update helps to improve future classifications. (3 marks)

Q2

- i. Explain what is *generalization* in neural networks. (4 marks)
- ii. Describe the following error measurements,
 - a. Specific error

- b. Euclidean distance error
 - c. RMS error (6 marks)
- iii. Compare and contrast *fully connected networks* and *partially connected networks*. (5 marks)
- iv. Consider a multilayer perceptron network with a single hidden layer including two neurons. The input layer is 3-dimensional $x = (x_1, x_2, x_3)$. The output layer includes one neuron (y). All neurons use weights, bias and ReLU units as activation functions.
Assume that all weights and biases are set to 0.1. The first input example is (1,2,1) and its output label is 1.
Using backpropagation algorithm, compute the updated gradient (Δb) of the bias of the output neuron after processing the first input example.

Use the following equations if required:

ReLU Function:

$$f(x) = \begin{cases} z & \text{if } z > 0 \\ 0 & \text{if } z \leq 0 \end{cases} \quad \text{derivative: } f'(x) = \begin{cases} 1 & \text{if } z > 0 \\ 0 & \text{if } z \leq 0 \end{cases}$$

$$\delta_k = \left(t_k - f\left(w_{ok} + \sum_{j=1}^p z_j w_{jk}\right) \right) f' \left(w_{ok} + \sum_{j=1}^p z_j w_{jk} \right)$$

$$\delta_{inj} = \sum_{k=1}^m \delta_k w_{jk}$$

$$\delta_j = \delta_{inj} f' \left(v_{oj} + \sum_{i=1}^n x_i v_{ij} \right) \quad (10 \text{ marks})$$

Q3

- i. Why is Hebbian learning considered an unsupervised learning method? (4 marks)
- ii. Briefly explain the following concepts,
 - a. Local minimum
 - b. Global minimum
 - c. Early stopping (6 marks)
- iii. An autonomous drone learns to navigate through obstacles by receiving rewards for successful movements and penalties for collisions.
Identify the learning paradigm used and explain how learning occurs in this system. (5 Marks)
- iv. Given the following for an *Adaptive Linear Element (ADALINE)* neuron.
 - Input vector: $\mathbf{x} = [1, 0.5]$
 - Weights: $\mathbf{w} = [0.4, -0.2]$
 - Bias: $\mathbf{b} = 0.1$

Learning rate: $\eta = 0.01$

Target output: $t = 1$

Using the Delta Rule, Calculate the updated weights and bias after one training iteration. (Show all the intermediate steps) (10 marks)

Q4

- i. Describe the three basic elements of an *artificial neuron model*. (4 marks)
- ii. Describe the following limitations of gradient descent,
 - a. Flat plateau
 - b. Oscillation
 - c. Overshooting(6 marks)
- iii. In a radar system, signals are affected by changing environmental conditions and background noise. Since these conditions vary continuously, the input data also changes over time. This is called a nonstationary environment. Real-time radar signal processing operates in such a dynamic environment where signal patterns and noise characteristics continuously vary.
Identify and explain at least two (02) properties of neural networks that make them suitable for operating effectively in such environments. (5 marks)
- iv. A Convolutional Neural Network (CNN) consists of several layers that work together to perform image classification tasks.
 - a. Identify the main layers of a CNN. (3 marks)
 - b. Explain the role of each layer in processing an input and producing the final output. (7 marks)

Q5

- i. What is the purpose of hidden layers in a *multilayer neural network*? (4 marks)
- ii. Describe the following concepts related to learning curves,
 - a. Training error curve
 - b. Validation error curve
 - c. Overfitting(6 marks)
- iii. Describe the similarities and differences between the *Perceptron* and *ADALINE* networks. (5 marks)
- iv. A company is developing an AI system to predict whether an employee is eligible for promotion based on three binary inputs:
 x_1 : Completed all assigned projects (1 = Yes, 0 = No)

- x₂: Attended all mandatory training sessions (1 = Yes, 0 = No)
 x₃: Received positive performance reviews (1 = Yes, 0 = No)

The system uses a single neuron with the following weights:

$$w_0 = 0.3(\text{bias}), w_1 = 0.5, w_2 = 0.4, w_3 = 0.6$$

- For an employee with input vector $x = [1, 1, 0, 1]$ (including $x_0 = 1$ for bias), compute the dot product of the input and weight vectors. (6 marks)
- What is the neuron's output after applying Leaky ReLu as the activation function? (4 marks)

Q6

- Briefly explain the *Delta Rule* used in neural network learning. (4 Marks)
- Explain the following learning approaches used in artificial neural networks,
 - Single-layer feedforward network
 - Multilayer feedforward network
 - Recurrent neural network
 (6 marks)
- The following feature map is obtained after a convolution operation:

$$\begin{bmatrix} 3 & 1 & 5 & 2 \\ 8 & 6 & 4 & 7 \\ 2 & 9 & 1 & 3 \\ 5 & 4 & 8 & 6 \end{bmatrix}$$

- Apply 2×2 max pooling with stride 2 and obtain the pooled output.
 - State one advantage of using max pooling in convolutional neural networks. (5 marks)
- A single neuron is used to classify input patterns into two classes. The decision boundary learned by the neuron is given by:

$$2x_1 - x_2 - 4 = 0$$
 - Determine the values of the weights and bias associated with this decision boundary. (2 marks)
 - For the input pattern $((3,1))$, determine whether it belongs to the positive response region or the negative response region. Show your calculations. (3 marks)
 - Explain the role of a decision boundary in pattern classification and discuss how the weights and bias influence its position and orientation. (5 marks)

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