THE OPEN UNIVERSITY OF SRI LANKA
BSc (IT) DEGREE PROGRAMME / BSc Hons (IT) DEGREE PROGRAMME: LEVEL 05
FINAL EXAMINATION: SEMESTER 1: 2024/2025
COU5300: ARTIFICIAL NEURAL NETWORKS

DURATION: **TWO HOURS** (2 HOURS)

DATE: **15.06.2025** TIME: **9.30 a.m. – 11.30 a.m.**

Answer ONLY FOUR (04) Questions.

Q1.

i. Describe the structure and function of an **artificial neuron** in an Artificial Neural Network (ANN). (5 Marks)

ii. Briefly explain the following terms in the context of Artificial Neural Networks.
   (a) Perceptron
   (b) Least mean square
   (c) Synapse
   (d) Weight sharing
   (e) Pooling (5 Marks)

iii. Compare and contrast a **biological neuron** with an **artificial neuron**. Highlight their structural components, functional similarities and differences. (5 Marks)

iv. A university education platform uses a basic neural network to predict student engagement with a new course. Two input features are considered:

X_1: Time spent on the platform (in hours per week)

X_2: Number of forum posts made by the student

The platform assigns weights to these inputs as follows:

$W_1 = 0.5$ (for time spent)

$W_2 = 0.3$ (for forum activity)

The bias (b) is set to 1

For a particular student:

$X_1 = 8$

$X_2 = 5$

Tasks:

(a) Summation Function:

Calculate the **net input (Z)** using the formula:

$$Z = (X1 \times W1) + (X2 \times W2) + b$$

(b) Activation Function:

Apply the ReLU activation function defined as:

$$f(Z) = \max(0, Z)$$

to compute the final output.

(c) Interpretation

What does the final output suggest about the student's engagement level?

(10Marks)

Q2.

i. Explain the different **learning paradigms** in Artificial Neural Networks (ANN). Provide examples for each paradigm.

(5 Marks)

ii. Define **Reinforcement Learning** in the context of Artificial Neural Networks. Explain its working mechanism with a suitable illustration.

(5 Marks)

iii. Discuss the criteria and conditions for stopping the learning process in Artificial Neural Networks (ANN). Explain why stopping at the right time is important, and describe common techniques used to determine when to stop training.

(5 Marks)

iv. At the university, a student is using an AI-based learning assistant that helps detect whether submitted assignments are original or plagiarized. The assistant is powered by a neural network trained using **Hebb's learning rule**, which strengthens the weights between neurons based on repeated patterns.

The network has:

- **Two input neurons** x1 (represents use of original content features) and x2 (represents use of suspicious phrases),
- **One output neuron** y (1 = original, 0 = plagiarized),

- **Initial weights:** w1=−0.4, w2=0.6,
- **Input values:** x1=1, x2=0,
- **Output:** y=1,
- **Learning rate:** η=0.2.

Using Hebb's rule:

$$\Delta wi=\eta xiy$$

Calculate the **updated weights** w1 and w2.

(10 Marks)

Q3.

i. Compare and contrast the **McCulloch-Pitts neuron** model and the **single-layer Perceptron** with proper diagram.

(5 Marks)

ii. Explain the role of **weights and biases** in Artificial Neural Networks (ANNs). Why are they essential for the learning and functioning of a neural network?

(5 Marks)

iii. Explain the **Perceptron Convergence** Theorem. Describe the steps involved in the Perceptron Learning Algorithm.

(5 Marks)

iv. Construct a single-layer Perceptron to implement the **OR** gate using the Perceptron Learning Algorithm. Explain each step of the algorithm and show how the final weights are obtained.

(10 Marks)

Q4.

i. What is **ADALINE** (Adaptive Linear Neuron) in the context of Artificial Neural Networks?

(5 Marks)

ii. Artificial Neural Networks (ANNs) rely on internal signal processing for learning and prediction. Describe the two key types of signals that exist in a neural network.

Explain their roles in the training and operation of the network, and discuss how they contribute to the overall learning process.

(5 Marks)

iii. Explain the functions of **hidden neurons** in a neural network.

(5 Marks)

iv. Use the **ADALINE** model to learn the scholarship eligibility decision function based on two binary student input features **x1** and **x2**. Use the following parameters:

- x1: Academic performance (1 = high GPA, 0 = low GPA)
- x2: Extracurricular involvement (1 = active, 0 = not active)

Use the following:

- Initial weights: w0=0.2, w1=0.2, w2=0.2
- Learning rate α=0.1
- Activation function: **linear** (no thresholding)
- Use **1 epoch** (1 pass over all training examples)
- Target function:

$$\text{Eligibility}(x1, x2) = \begin{cases} 1 \text{ if } x1=1 \text{ and } x2=1 \\ 0 \text{ otherwise} \end{cases}$$

Inputs include bias as x0=1

Compute the **weight updates** for 1 epoch.

(10 Marks)

Q5.

i. Describe the structure and working principle of Radial Basis Function networks. Explain their key components with the help of a suitable illustration.

(5 Marks)

ii. Compare and contrast **Radial Basis Function** (RBF) Networks and **Multilayer Perceptron** (MLPs)

(5 Marks)

iii. Explain the concepts of **dot products** and **vector addition** in the context of Artificial Neural Networks.

(5 Marks)

iv. A university is developing an AI system to predict whether a student will pass a course based on three binary inputs:

- x1: Attended more than 75% of lectures (1 = Yes, 0 = No)
- x2: Submitted all assignments (1 = Yes, 0 = No)
- x3: Participated in class discussions (1 = Yes, 0 = No)

The system uses a single neuron with the following weights:

w0=−0.4 (bias), w1=0.6, w2=0.7, w3=0.5

For a student with input vector x=[1,1,1,0], (including x0=1 for bias), compute the **dot product** of the input and weight vectors.

What is the output before applying any activation function?

(10 Marks)

Q6.

i. In the design of **Artificial Neural Networks** (ANNs), the **Dense (fully connected) layer** plays a critical role in learning and information processing. Explain the concept of the Dense layer in ANNs.

(5 Marks)

ii. The Backpropagation algorithm is fundamental to the training of Artificial Neural Networks. Describe the **two (02)** main phases of the **Backpropagation algorithm**

(5 Marks)

iii. What is a **Convolutional Neural Network** (CNN)?

(5 Marks)

iv. Describe the main layers of a **Convolutional Neural Network** (CNN) and explain the role of each layer.

(10 Marks)