

**Instructions:** All questions are compulsory. Use of non-programmable scientific calculator is allowed.

- Q.1** (a) Explain in detail the basic structure of Perceptron. (07)  
 (b) What are the different types of activation functions popularly used? Explain each of them. (07)
- OR**
- (a) Define deep learning and explain how it differs from traditional machine learning approaches. (07)  
 (b) Explain, in detail, the basic structure of Multi-Layer Perceptron. (07)
- Q.2** (a) Describe the backpropagation algorithm and its significance in training ANNs. (07)  
 (b) A neuron has two binary inputs and uses a threshold activation function. Its weights are  $w_1 = -1$  and  $w_2 = 2$ , and the bias is  $b = -0.5$ . Determine the output of the neuron for each of the following inputs: (0, 0), (1, 0), (0, 1), and (1, 1). Also, identify the logical function (if any) this neuron is computing. (07)
- OR**
- (a) Describe the theoretical and practical impact of batch normalization, including their mathematical formulations and roles in model training. (07)  
 (b) What is the vanishing and exploding gradient problem? Provide an example where the gradients vanish for the sigmoid activation function. (07)
- Q.3** (a) Compare and contrast Convolutional Neural Networks (CNNs) and Deep Neural Networks (DNNs) in terms of their architectural characteristics, methods of processing data, and common application areas. (07)  
 (b) A Convolutional Neural Network (CNN) receives an input image of size  $32 \times 32 \times 3$ . The network is composed of the following layers: (07)
- Convolutional Layer 1: 16 filters of size  $5 \times 5$ , stride 1, padding 2
  - Max Pooling Layer 1:  $2 \times 2$  window, stride 2
  - Convolutional Layer 2: 32 filters of size  $3 \times 3$ , stride 1, padding 1
  - Max Pooling Layer 2:  $2 \times 2$  window, stride 2
  - Fully Connected Layer: 256 neurons
  - Output Layer: 10 neurons for classification
- Answer the following:
- Calculate the output dimensions (height  $\times$  width  $\times$  depth) after each layer.
  - Calculate the total number of trainable parameters (weights + biases) in each convolutional and fully connected layer.
  - What is the total number of trainable parameters in the entire network?
- OR**
- (a) Explain the working of dropout, including their mathematical operations and regularizing effects. (07)  
 (b) Discuss the concept of receptive fields in CNNs. How does it relate to feature extraction and spatial hierarchy in image data? (07)

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- Q.4** (a) Describe the different categories of sequence modeling. Provide examples of tasks associated with each category. (07)
- (b) Explain the working of a vanilla RNN and its layer structure, with a neat diagram showing its memory of previous inputs. (07)
- OR**
- (a) What are the advantages and disadvantages of Recurrent Neural Networks (RNNs) in sequence modeling tasks (07)
- (b) Explain the internal structure of an LSTM cell using a well-labeled diagram. (07)
- Q.5** Attempt any **SEVEN** out of **TWELVE**: (14)
- (1) Why is linear activation not suitable for classification problems?
  - (2) Compute the total number parameters (Weights and bias) when Layer sizes: 10, 16, 16, 16, 2.
  - (3) What is the key idea behind Momentum optimization?
  - (4) How does AdaGrad differ from standard gradient descent?
  - (5) What makes Adam the most popular optimizer in deep learning?
  - (6) Describe the concept of "weight sharing" in convolutional layers and explain its main benefits.
  - (7) Why is padding commonly used in convolutional layers, and what is its general effect on the output dimensions?
  - (8) Distinguish between Max Pooling and Average Pooling in terms of their operation and typical use cases.
  - (9) What problem did ResNet primarily address, and what architectural innovation did it introduce to solve it?
  - (10) Distinguish between sequence data and time series data.
  - (11) Illustrate exploding gradient problem in RNN.
  - (12) What distinguishes a Gated Recurrent Unit (GRU) from a Long Short-Term Memory (LSTM) network?

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