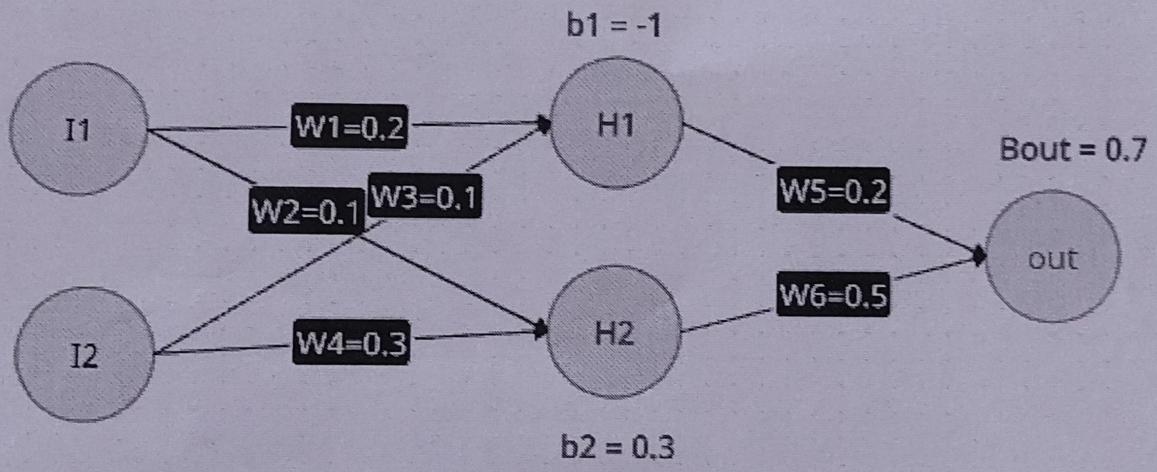
NATIONAL INSTITUTE OF TECHNOLOGY, TIRUCHIRAPPALLI – 620015
DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
B.Tech – End Semester Exam
CSPE72 - DEEP LEARNING TECHNIQUES

Date: 11.11.2025 **Time: 9.30 pm to 12.30 pm** **Max.Marks: 40**

Answer all questions

1. a. Show mathematically that a single-layer perceptron cannot solve the XOR logic problem, regardless of how its weights and bias are chosen. (2)
   b. Calculate the output Y of a three-input neuron with bias. The input feature vector is (xl, x2, x3): (0.8, 0.6, 0.2), the weight values are [wl, w2, w3]: [0.2, 0.1, -0.3], and the Bias is 0.25. Use the binary sigmoid, Tanh, and ReLU activation functions. (3)
   c. Update the parameters in the given MLP using back propagation with a learning rate of 0.5 and an activation function as sigmoid. The initial weights and biases are shown in the diagram below. The input = [0.6, 0.9], and the target output =1. (3)



   d. Which regularization method leads to weight sparsity? Explain why. (1)

2. a. Assume an input volume of dimension 64 x 64 x 3. What are the dimensions of the resulting volume after convolving a 5 x 5 kernel with zero padding, a stride of 1 and 2 filters? (3)
   b. What is the role of Backpropagation Through Time (BPTT) in training RNNs, and how does it work? (3)
   c. Explain the importance of choosing the right step size in the neural network. (2)

3. a. How does ICA handle non-Gaussian signals compared to PCA, and why is this important for signal separation? (2)
   b. Explain the concept of a Variational Autoencoder and describe its working mechanism with its loss function. (3)
   c. Explain the difference between Vanilla Autoencoders and Undercomplete Autoencoders (2)

4. a. Describe the structure and working mechanism of a Boltzmann Machine. (3)
   b. Explain the concept of Zero-Shot Learning (ZSL) and discuss how it utilizes Transfer Learning. (3)
   c. Explain why pre-trained CNNs like VGG or ResNet are widely used in transfer learning applications. (2)

a. Consider a Convolutional Neural Network (CNN) composed of the layers listed below. (3)
For each layer, determine:

1. The output activation volume dimensions in the format (H, W, C), where H = height, W = width, and C = number of channels.
2. The number of learnable parameters in that layer.

Unless otherwise specified, assume padding = 1 and stride = 1 for all convolutional layers.

Notation:

- CONVx-N denotes a convolutional layer with N filters with height and width equal to x.
- POOL-n denotes an n x n max-pooling layer with a stride of n and 0 padding.
- FLATTEN flattens its inputs, identical to torch.nn.flatten / tf.layers.flatten.
- FC-N denotes a fully-connected layer with N neurons

Layer Activation	Output Volume (H, W, C)	Number of parameters
Input	32 x 32 x 3	0
CONV3-8		
Leaky ReLU		
POOL-2		
BATCHNORM		
CONV3-16		
Leaky ReLU		
POOL-2		
FLATTEN		
FC-10		

Fill in the output volume dimensions and the number of parameters for each layer in the table above.

b. You are given a content image of a cityscape X_C, and a style image of a famous painting X_S. Explain how Neural Style Transfer can generate a new image X_Y that preserves the structure of the city while adopting the artistic patterns of the painting. (3)

c. Describe how Multi-Head Attention improves the performance of a Transformer compared to single-head attention. (2)