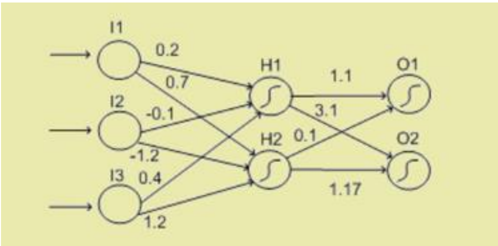
<table>
<tr><th>Q. No.</th><th>Description</th><th>Marks</th><th>Course Outcome (1-5)</th><th>Competency Levels (1-6)</th><th>AHEP LO LEVELS</th></tr>
<tr><td>1A</td><td>

Using the back-propagation algorithm, find new weights for the following network [perform one iteration]. Input pattern [10, 30, 20], target output: [O1=1, O2=0], learning rate =0.1. Activation Function: Sigmoid function



</td><td>5</td><td>1</td><td>6</td><td>2,3</td></tr>
<tr><td>1B</td><td>

Below is a diagram of a single artificial neuron (unit):

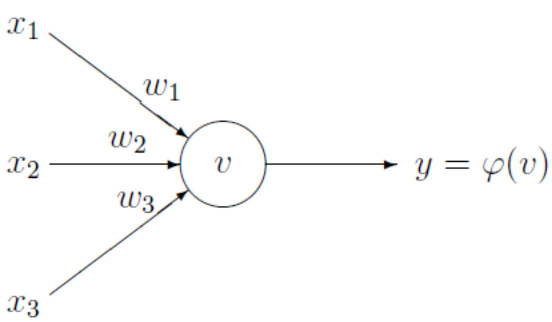


Figure 1: Single unit with three inputs.

The node has three inputs x = (x1; x2; x3) that receive only binary signals (either 0 or 1).

(i) How many different input patterns this node can receive? What if the node had four inputs? Five? Can you give a formula that computes the number of binary input patterns for a given number of inputs?

(ii) Consider the unit shown in Figure 1. Suppose that the corresponding weights to the three inputs have the following values:

</td><td>3</td><td>1</td><td>5</td><td>2,3</td></tr>
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$$\begin{array}{rcl} w_1 & = & 2 \\ w_2 & = & -4 \\ w_3 & = & 1 \end{array}$$

Calculate the output value y of the unit for each of the following input patterns:

The activation function is the step function.

<table>
<tr><th>Pattern</th><th>P_1</th><th>P_2</th><th>P_3</th><th>P_4</th></tr>
<tr><td>x_1</td><td>1</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td>x_2</td><td>0</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>x_3</td><td>0</td><td>1</td><td>1</td><td>1</td></tr>
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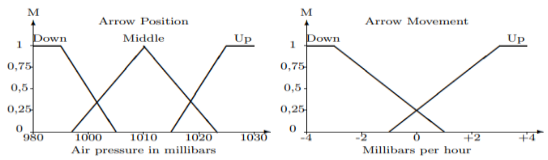
</td><td></td><td></td><td></td><td></td></tr>
<tr><td>1C</td><td>Explain the operations of an artificial neuron.</td><td>2</td><td>1</td><td>2</td><td>2,3</td></tr>
<tr><td>2A</td><td>Describe in detail the structure and components of a standard Radial Basis Function (RBF) network and discuss the advantages and disadvantages of RBF networks compared to multilayer perceptrons.</td><td>5</td><td>2</td><td>2</td><td>2,3,6</td></tr>
<tr><td>2B</td><td>Explain memory-based learning. How does the k-nearest Neighbor Rule function in memory-based learning, and discuss its advantage over the Nearest Neighbor Rule?</td><td>3</td><td>1</td><td>2</td><td>2,3</td></tr>
<tr><td>2C</td><td>

Consider the following fuzzy expert system for weather forecast:

<table>
<tr><th>Rule</th><th>Condition</th><th>Action</th><th>Confidence</th></tr>
<tr><td>R1:</td><td>IF arrow is down</td><td>THEN clouds</td><td>$M = 0.8$</td></tr>
<tr><td>R2:</td><td>IF arrow is in the middle AND moving down</td><td>THEN clouds</td><td>$M = 0.6$</td></tr>
<tr><td>R3:</td><td>IF arrow is in the middle AND moving up</td><td>THEN sunny</td><td>$M = 0.6$</td></tr>
<tr><td>R4:</td><td>IF arrow is up</td><td>THEN sunny</td><td>$M = 0.8$</td></tr>
</table>

The following two plots represent the membership functions of two fuzzy variables describing the position of the arrow of barometer (left) and the direction of its movement (right):



The air pressure is measured in millibars and the speed of its change in millibars per hour. Answer the following questions:

(a) How much is the arrow Down, Up or in the Middle if it indicates that the pressure is 1020 millibars? Use membership functions on the graphs.

(b) How much is the arrow moving Down or Up if the pressure changes -2 millibars every hour?

</td><td>2</td><td>3</td><td>5</td><td>2,3</td></tr>
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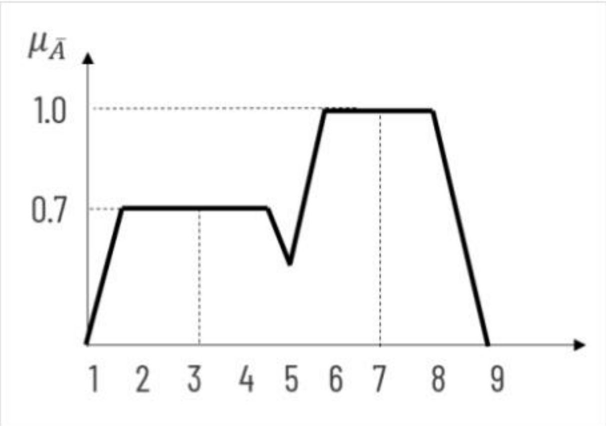
3A	Explain the rank-based selection method and how it differs from the tournament selection method. Consider a genetic algorithm with a population consisting of four individuals, each characterized by a fitness value: 0.40, 0.05, 0.03, and 0.02. Employing the rank-based selection method, determine the selection probabilities for each individual.	**5**	**4**	**5**	**2,3,6,12**
3B	Describe the concept of linear crossover in real-coded genetic algorithms, along with its advantages and limitations. Calculate the values of two offspring generated using the linear crossover technique in a real-coded genetic algorithm. The parent individuals denoted as P1 and P2, have parameter values of P1=14.2 and P2=19.54, respectively. The crossover operation employs the following parameters α1=0.2 and β1=0.4, and α2 =0.6 and β2=0.7.	**3**	**4**	**5**	**2,3,6,12**
3C	Calculate the defuzzified value for the aggregated fuzzy output set depicted in the figure using the weighted average method.  	**2**	**3**	**5**	**2,3**
4A	The rule base to be followed for a neuro-fuzzy system is given in the below Figure where I1 and I2 are inputs and O is the output of the controller. The neural network will consist of five layers. The input I1 has been expressed using three linguistic terms: Low (LW), Medium (M) and High(H). Similarly, the input I2 has been expressed using four linguistic terms: Very near (VN), Near(N), Far(FR), and Very Far (VFR). The output has been expressed using three linguistic terms: Slow(S), Fast(F), and Very Fast(VF). Draw a neural network that assists to design a fuzzy logic controller for a neuro-fuzzy system and explain the operation of each layer.	**5**	**5**	**6**	**2,3,6**

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<tr><td></td><td></td><td colspan="4">I_2</td></tr>
<tr><td></td><td></td><td>VN</td><td>NR</td><td>FR</td><td>VFR</td></tr>
<tr><td rowspan="3">I_1</td><td>LW</td><td>S</td><td>S</td><td>F</td><td>F</td></tr>
<tr><td>M</td><td>S</td><td>F</td><td>F</td><td>VF</td></tr>
<tr><td>H</td><td>S</td><td>F</td><td>VF</td><td>VF</td></tr>
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<td>4B</td>
<td>Explain the following terms.

i) Modular Neural Networks

ii) Neuro-Fuzzy Hybrid systems</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>2,3,6</td>
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<tr>
<td>4C</td>
<td>Explain the role of crossover in genetic algorithms. Describe the basic principle of matrix crossover operation in genetic algorithms.</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>2,3,6,12</td>
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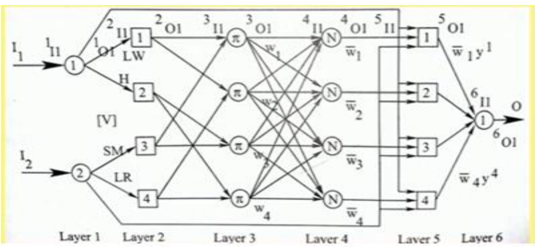
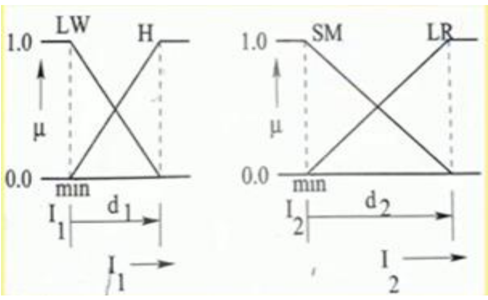
<td>5A</td>
<td>Consider the schematic view of an ANFIS (shown in the below figure) used for modeling a process with two inputs, I_1 and I_2, and one output, O. The network comprises six layers. Two linguistic terms, Low (LW) and High (H), represent the first input, I_1, while the second input, I_2, is expressed using two linguistic terms: Small (SM) and Large (LR). The connecting weights (expressed in normalized form from 0 to 1) between the nodes of the first and second layer are denoted by the [V] matrix



The membership function distribution of the input variables is assumed to be triangular in nature.



The starting values of I_1 and I_2 are assumed to be 1.0 units and 5.0 units, respectively. For simplicity, it has been assumed that $V_{11}=V_{12}$, and $V_{23}=V_{24}$.</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>2,3, 6</td>
</tr>
</table>

Moreover, the d_1 and d_2 are real values corresponding to the normalized weights $V_{11}=V_{12}$, and $V_{23}=V_{24}$, respectively. According to the first order Takagi and Sugeno's model of FLC , the rules can be expressed as follows

$$y^i = a_i I_1 + b_i I_2 + c_i,$$

where i = 1, 2, 3, 4 ; a_i, b_i, c_i are the coefficients of the rules.

The rules are given as follows:

Rule Number	a_i	b_i	c_i
1	0.2	0.3	0.10
2	0.2	0.4	0.11
3	0.3	0.3	0.13
4	0.3	0.4	0.14

The values of the d_1 and d_2 vary in the ranges as below:

$$0.8 \le d_1 \le 1.5 \; ; \; 4.0 \le d_2 \le 6.0$$

Assume the normalized weight values as follows:

$$[\, v_{11} = v_{12} \quad v_{23} = v_{24} \,]^T = [0.3 \;\; 0.5]^T$$

and determine the deviation in prediction for the training scenario.

$$I_1 = 1.1, \; I_2 = 6.0 \text{ and Output } O = 2.3$$

5B	Define Hybrid Systems and what are their various types? Provide an in-depth explanation of a specific hybrid system, highlighting its components and functioning.	**3**	**5**	**2**	**2,3,6**
5C	Explain the mutation operations utilized within a binary-coded genetic algorithm.	**2**	**4**	**2**	**2,3,6,12**

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