SOFT COMPUTING
(AEIE 4132)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) The truth values of traditional set theory can be defined as _____ and that of fuzzy logic is termed as _____.
(a) Either 0 or 1, either 0 or 1 (b) Between 0 & 1, either 0 or 1
(c) Either 0 or 1, between 0 & 1 (d) Between 0 & 1, between 0 & 1

(ii) The weather is very hot. Here 'hot' (use of linguistic variable) can be represented by _____.
(a) Fuzzy Set (b) Crisp Set
(c) Fuzzy & Crisp Set (d) None of the mentioned

(iii) Which of the following represents the values of set membership?
(a) Degree of truth (b) Probabilities (c) Discrete set (d) Both (a) & (b).

(iv) If $\mu_B(x) = \{(x_1,0.1),(x_2,0.3),(x_3,0.02)\}$ Then complement of x_2 would be
(a) 0.7 (b) 0.02 (c) -0.3 (d) 0.1.

(v) Which of the following fuzzy operators are utilized in fuzzy set theory?
(a) AND (b) OR (c) NOT (d) All of the above.

(vi) Swimming of tadpole is an example of _____ learning.
(a) unsupervised (b) reinforce (c) supervised (d) competitive

(vii) The number of nodes present in a hidden layer in BPNN is_____ .
(a) 10 (b) any numbers (c) 1 (d) 100

(viii) Which is true for neural networks?
(a) It has set of nodes and connections
(b) Each node computes it's weighted input
(c) Node could be in excited state or non-excited state
(d) All of the mentioned.

(ix) What is the name of the process that represents modified elements of the DNA?
(a) Selection (b) Mutation (c) Recombination (d) None of the above.

(x) Name the input function received by neurons, which is also known as the neuron's internal state.

(a) Weight (b) Bias

(c) Activation or neuron's activity level (d) None of the above.

Group - B

2. (a) Demonstrate triangular type membership function with appropriate diagram and show the mathematical formulation. [(CO2)(Understand/LOCQ)]

(b) Graphically represent the following membership functions and express mathematical relations for them:

(i) the notion of being baby; μ_{baby}(age)

(ii) the notion of feeling cold; μ_{cold}(temp)

(iii) the notion of steady state in a process; μ_{ss}(process output).

[(CO1)(Analyze/IOCQ)]

3 + (3 + 3 + 3) =12

3. (a) What is multi-valued logic and how it is different from Boolean logic? Justify your answer with example. [(CO1)(Understand/LOCQ)]

(b) Find the view of the Threshold, Conservatives and Estimator persons for the question "whether 14 is a large number?" in a set of 20 numbers [0,1,2,3, …..,20]. [(CO1)(Understand/LOCQ)]

(c) A number set is defined by N$\in$[10, 20,30,40,50,60,70,80,90,100].

(i) Apply your knowledge to derive the closeness membership functions of the set elements with respect to the number "50'.

(ii) Also draw the membership function plots of the set N in terms of smallest and largest numbers. [(CO1)(Analyze/IOCQ)]

3 + 3 + (3 + 3) = 12

Group - C

4. (a) Two relational matrix are mentioned as R1 and R2,

$$R1(x,y)=\begin{vmatrix}0.1 & 0.2 & 0.3\\ 0.4 & 0.5 & 0.9\\ 0.7 & 0.8 & 0.1\end{vmatrix} \text{ and } R2(y,z)=\begin{vmatrix}0.9 & 0.8\\ 0.7 & 0.6\\ 0.1 & 0.3\end{vmatrix}$$

Apply Fuzzy Max-Min Operator to calculate R3(x, z). [(CO3)(Analyze/IOCQ)]

(b) From the given fuzzy sets M and N, derive two dimensional relation matrices using Dienes- Rescher and Lukasiewicz fuzzy implications. [(CO3)(Analyze/IOCQ)]

$$M=\left\{\frac{0.2}{x_1}+\frac{0.5}{x_2}+\frac{0.8}{x_3}+\frac{0.4}{x_4}\right\}$$

$$N=\left\{\frac{0.1}{y_1}+\frac{0.3}{y_2}+\frac{0.7}{y_3}\right\}$$

5 + (4 + 3) = 12

5. Develop a fuzzy PD controller through the following steps:
   (i) Evaluate two inputs: error and change of error from a temperature process.
   (ii) Apply normalization.
   (iii) Design a fuzzification module for two input system.
   (iv) Develop a rule matrix for the 2nd order underdamped temperature system.
   (v) Choose any suitable defuzzification method to calculate output.

[(CO3)(Create/HOCQ)]

2 + 1 + 3 + 3 + 3 = 12

Group - D

6. (a) A sigmoidal neuron with steepness factor of 1.5, has two input weights 0.5 and 0.75 respectively.
   For an input X = (-1, 0.5), determine the value of the bias weight such that the neuron output is 0.8. Consider bias value =1. [(CO4)(Evaluate/HOCQ)]
   (b) Explain multilayer neural network with diagram. [(CO4)(Understand/LOCQ)]
   (c) Compare multilayer neural network with recurrent neural network with diagram.

[(CO4)(Understand/LOCQ)]

4 + 4 + 4 = 12

7. (a) Outline differences between BPNN and RBFN by drawing their architecture.

[(CO5)(Understand/LOCQ)]

   (b) Demonstrate the steps of back propagation neural network (BPNN) to notice the weight change in the network in presence of error. [(CO5)(Analyze/IOCQ)]
   (c) Inspect the importance of learning rate in back propagation neural network.

[(CO5)(Analyze/IOCQ)]

(2 + 2) + 6 +2 = 12

Group - E

8. (a) Demonstrate genetic algorithm step by step with a flowchart.

[(CO6)(Understand/LOCQ)]

   (b) Illustrate the different steps to design a neuro-fuzzy hybrid system with diagram.

[(CO5)(Analyze/IOCQ)]

6 + 6 = 12

9. (a) Suppose a genetic algorithm uses chromosomes of the form $x = abcdefgh$ with a fixed length of eight genes. Each gene can be any digit between 0 and 9. Let the fitness of individual x be calculated as: $f(x) = (a + b) - (c + d) + (e + f) - (g + h)$, and let the initial population consist of four individuals with the following chromosomes:

$$x_1 = 6\ 5\ 4\ 1\ 3\ 5\ 3\ 2$$
$$x_2 = 8\ 7\ 1\ 2\ 6\ 6\ 0\ 1$$
$$x_3 = 2\ 3\ 9\ 2\ 1\ 2\ 8\ 5$$
$$x_4 = 4\ 1\ 8\ 5\ 2\ 0\ 9\ 4$$

Evaluate the fitness of each individual, showing all your workings, and arrange them in order with the fittest first and the least fit last. [(CO6)(Evaluate/HOCQ)]

(b) Analyze the following crossover operations:
   (i) Cross the fittest two individuals using one–point crossover at the middle point.
   (ii) Cross the second and third fittest individuals using a two–point crossover (points b and f).
   (iii) Cross the first and third fittest individuals (ranked 1st and 3rd) using a uniform crossover. [(CO6)(Analyze/IOCQ)]

(c) Suppose the new population consists of the six offspring individuals, received from the crossover operations of the above question. Derive the fitness of the new population, showing all your workings. Has the overall fitness improved? [(CO6)(Analyze/IOCQ)]

(d) By looking at the fitness function and considering that genes can only be digits between 0 and 9 choose the chromosome representing the optimal solution (i.e. with the maximum fitness). Determine the value of the maximum fitness. [(CO6)(Understand/LOCQ)]

(e) By looking at the initial population of the algorithm, Examine whether it will be able to reach the optimal solution without the mutation operator. [(CO6)(Understand/LOCQ)]

2 + 3 + 3 + 3 + 1 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	32.29	48.96	18.75

Course Outcome (CO):

After the completion of the course students will be able to

1. Classify the soft-computing into the different computing methods based on their application, knowledge-base, mode of operation, construction, etc.
2. Explain the functions and properties of different fuzzy sets and compare with crisp set, explain different fuzzy relations and implications.
3. Design and analyze the different components of fuzzy controller appropriately to develop the best possible fuzzy controller that can be applied to any process control systems.
4. Identify different component of biological and artificial neural network, and acquire knowledge of different ANN terminologies to apply in solving control problems.
5. Analyze and design algorithms for different supervised and unsupervised learning networks.
6. Illustrate the biological background and give idea about the basics of genetic algorithm and its application in optimizing system parameters.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.