SOFT COMPUTING
(AEIE 4132)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

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

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) Which of the following is associated with fuzzy logic?
(a) Crisp set logic (b) Many-valued logic
(c) Two-valued logic (d) Binary set logic.

(ii) _____ represents the fuzzy logic
(a) IF-THEN rules (b) IF-THEN-ELSE rules
(c) Both (a) & (b) (d) None of (a), (b) & (c)

(iii) The weather is very hot. Here the hot membership function (MF) can be represented by
(a) Bell shaped MF (b) Gaussian MF
(c) Triangular MF (d) Increasing MF.

(iv) If $\mu_A(x) = \{(x_1,0.2), (x_2,0.5), (x_3,1),(x_4,0),(x_5,0.1)\}$; Then $A_{(\alpha=0.5)}$ is
(a) x_1, x_3, x_4, x_5 (b) x_2, x_3, x_4, x_5 (c) x_2, x_3 (d) x_3.

(v) In a fuzzy controller, if error is positive and change of error is negative, the control output should be
(a) positive (b) negative (c) zero (d) in can be any value.

(vi) ANN receives n (*i=1 to n*) inputs $\{x_1,x_2,.....,x_n\}$having weights $\{w_1,w_2,.....,w_n\}$. The weighted sum computed is _____.
(a) Σw_i (b) Σx_i (c) $\Sigma w_i + \Sigma x_i$ (d) $\Sigma w_i * x_i$.

(vii) Automated vehicle is an application of _____
(a) unsupervised learning (b) supervised learning
(c) reinforcement learning (d) active learning.

(viii) A 3-input neuron is trained to output a 0 when the input is 110 and a 1 when the input is 111. After generalization, the output will be 0, when and only when the input is
(a) 000 or 110 or 011 or 101 (b) 000 or 010 or 110 or 100
(c) 100 or 111 or 101 or 001 (d) 010 or 100 or 110 or 101.

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

(x) Genetic algorithms are example of
(a) heuristic (b) evolutionary algorithm
(c) particle swarm optimization (d) ant colony optimization.

Fill in the blanks with the correct word

(xi) If $\mu_A(x) = \{(x_1, 0.01), (x_2, 0.5)\}$; $\mu_A^c(x_1)$ is _____.

(xii) In ANN, Neurons interconnected among multiple network layers are referred to as _____.

(xiii) A 4-input neuron linear in nature has weights 1, 2, 3, and 4. The constant of proportionality being equal to 2. The inputs are 1, 0, 1, and 1, respectively. The output will be _____.

(xiv) The complexity of ANN is dependent upon _____.

(xv) Chromosomes are basically the strings of _____.

Group - B

2. (a) Demonstrate Pie-type membership function with appropriate sketch and mathematical formulation. *[(CO1)(Understand/LOCQ)]*

(b) Represent the following membership functions with your expertization both graphically and logically.
(i) Set of small number in set A, consisting of natural numbers ≤8
(ii) Comfortable temperature in room air-conditioner. *[(CO1)(Analyze/IOCQ)]*

(c) How fuzzy set is different from conventional set? *[(CO1) (Understand/LOCQ)]*

(2 + 2) + (3 + 3) + 2 = 12

3. (a) Explain the concept of Heap Paradox in context of fuzzy membership function. *[(CO1)(Understand/LOCQ)]*

(b) Given two fuzzy sets U∈X and V∈Y with elements [1,2,3,4] and [1,2,3,4] respectively. Derive the relational membership function $\mu_R(u,v)$ for "u considerably smaller than v". *[(CO2)(Analyze/IOCQ)]*

(c) Derive $\mu_{C\cup D}(R)$, $\mu_{C\cap D}(R)$ for the given two dimensional fuzzy sets C and D.

$$C = \left\{\frac{0.2}{x_1} + \frac{0.0}{x_2} + \frac{0.9}{x_3} + \frac{0.4}{x_4}\right\}$$

$$D = \left\{\frac{0.1}{y_1} + \frac{0.3}{y_2} + \frac{0.7}{y_3} + \frac{1}{y_4}\right\}$$

[(CO2)(Analyze/IOCQ)

2 + 4 + (3 + 3) = 12

Group - C

4. (a) Determine relation matrix $\mu_{R_C}(x,y)$ from the given two fuzzy sets using Mamdani and Zadeh implication.

$$\mu_A(x)=\left\{\frac{0.5}{x_1}+\frac{0.9}{x_2}+\frac{0.1}{x_3}\right\} \text{ and } \mu_B(y)=\left\{\frac{0.7}{y_1}+\frac{0.3}{y_2}+\frac{0.5}{y_3}\right\}$$ *[(CO3)(Analyze/IOCQ]*

(b) Fuzzy set 'A' is defined by $\mu_A(x)=\left\{\frac{0.3}{x_1}+\frac{0.4}{x_2}+\frac{0.7}{x_3}\right\}$ and the corresponding relation matrix '$\mu_R(x,y)$' is represented by

R =

	Y_1	Y_2	Y_3	y_4
X_1	0.8	1	0.1	0.7
X_2	0	0.8	0	0
X_3	0.9	1	0.7	0.8

where μ_R is defined as $\mu_R : \tilde{A}\times\tilde{B}\in[0,1]$.

Estimate fuzzy set $\mu_B(y)$ using composition operator from the above supplied data. *[(CO2)(Evaluate/HOCQ)]*

(2 + 4) + 6 = 12

5. (a) When should we use fuzzy controller in place of conventional controllers? *[(CO3)(Understand/LOCQ)]*

(b) What is normalization and denormalization in fuzzy controller design? *[(CO3)(Remember/LOCQ)]*

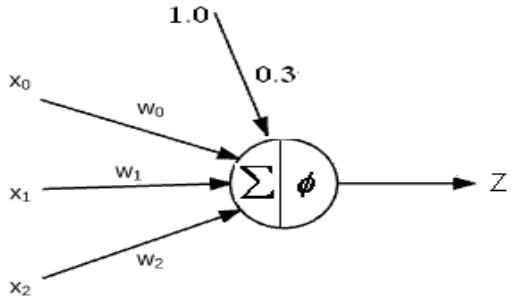
(c) Evaluate the mathematical expression of fuzzy PD controller. Apply the equation of fuzzy PD controller to derive the expression of fuzzy PI controller. *[(CO3)(Evaluate/HOCQ)]*

(d) Explain the Centre of Area defuzzification procedure. *[(CO3)(Understand/LOCQ)]*

2 + 3 + (2 + 3) + 2 = 12

Group - D

6. (a) A single layer neural network with 3 inputs and 1 output with a bias is shown in fig. below.
Determine the output (Z) from the network if the activation functions are:
(i) binary sigmoidal and (ii) bipolar sigmoidal.
The inputs values (x_o, x_1, x_2) are 0.8, 0.6 and 0.4 respectively and their corresponding synaptic weights (w_o, w_1, w_2) are 0.1, 0.3 and -0.2.



[(CO4)(Apply/IOCQ)]

(b) Draw a Perceptron network with 3 inputs, 1 output and 1bias input. State the training algorithm for this Perceptron network. *[(CO5)(Understand/LOCQ)]*

(3 + 3) + (3 + 3) = 12

7. (a) Demonstrate the architecture of a Radial Basis Function Network (RBFN). *[(CO5)(Understand/LOCQ)]*

(b) Explain the RBFN process for the given output equation $y(X)=\sum_{i=1}^{M} w_i \left(\frac{\left(\|X-c_i\| \right)^2}{2\sigma^2} \right)$

Where the input is x, and the corresponding output is y(x). c and σ represent the mean value and base-width respectively. *[(CO5)(Analyze/IOCQ)]*

(c) Analyze the importance of learning rate in back propagation neural network. *[(CO4)(Understand/LOCQ)]*

3 + 6 + 3 = 12

Group - E

8. A genetic algorithm develops population / chromosomes of the form t = abcxyz with a fixed length of six genes. Each gene can be any digit between 0 and 7. The proposed fitness function of individual chromosome is calculated from the relation:
f(t) = (a + b+c) − (x+y)+z
Answer the following questions for the above problem statement.
(i) Generate six chromosomes as population.
(ii) Calculate fitness values.
(iii) Apply single point crossover at the midpoint between 1st and 3rd fittest chromosoes.
(iv) Apply multipoint crossover (at b,x and z position) between 2nd and 4th ranked chromosomes.
(v) What is the maximum fitness value of the chromosome is possible in this setup? *[(CO6)(Analyze/IOCQ)]*

(2 + 3 + 2 + 3 + 2) = 12

9. (a) Explain the local optimum problem in a genetic algorithm. *[(CO6)(Understand/LOCQ)]*
(b) Explain the following steps in genetic algorithm with example:
(i) Initialization (ii) Fitness function (iii) Selection (iv) Crossover (v) Mutation. *[(CO6)(Understand/LOCQ)]*

2 + (2 × 5) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	40.62	47.91	11.45

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.*