End-Semester Examination
Intelligent Computing (CSE 342)
(Odd Semester 2022-23)

18123007

Full Marks: 60 **Time: 3 hours**

[Give precise answers to all questions. All parts of a question must be answered together. Use of calculator is allowed]

Q1. In Genetic Algorithm, Roulette wheel selection is one of the selection methods. Calculate and fill in the missing cells marked as '-' in the table given below for Roulette wheel selection.

Serial Number	Chromosome	Fitness	% of Total Fitness (rounded up to 1 decimal place)
1	101101	234	-
2	011001	-	37.3
3	100100	211	15.0
4	110010	-	-
5	101111	-	22.9
Total		1404	100

[5 marks]

Q2: Suppose a Genetic Algorithm uses fixed length chromosomes of eight genes, where each gene value can be any digit between 0 to 9. The fitness of a particular chromosome x encoded as <abcdefgh> is computed as:

$$\mathbf{f(x) = (a + b) - (c + d) + (e + f) - (g + h).}$$

Let the initial population consists of the following four individuals:

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

a) Evaluate the fitness of each individual in the above population. Rank these in order of their fitness values with the fittest first and the least fit last. [*Assume that a higher value of fitness indicates the chromosome is more fit.*] **[4+2 = 6 marks]**

b) Consider that the entire population is copied to a mating pool. Now, perform the following crossover operations:

i) Cross the fittest two individuals using single-point crossover about the middle point.

ii) Cross the second and third fittest individuals using two-point crossover (the two points are after positions b and f). **[2+2 = 4 marks]**

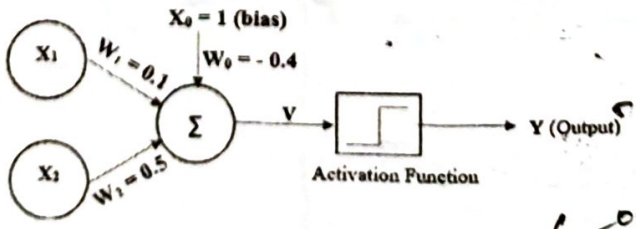
c) Suppose the new population in the next generation consists of the four offspring individuals received after applying the crossover operations in the previous step. Evaluate the fitness of each individual in the new population. Has the overall average fitness improved? **[4+1 = 5 marks]**

Q3. A single layer perceptron neural network is used to classify a two input OR function as shown in Table 1 with initial weights as shown in Figure 1.

Table 1: Two-input OR Function

Pattern Number	X_1	X_2	Desired Output
1	0	0	0
2	0	1	1
3	1	0	1
4	1	1	1

Using a learning rate of 0.1, train the neural network till convergence using the same sequence of patterns given in Table 1. With reference to Figure 1, consider the activation function as Y = {1 if V > 0, else 0}



[6 marks]

Figure 1: A Single Layer Perceptron with initial setting of the weights

Q4. a) What are the two major goals in multi-objective optimization?

b) When do we say that a solution $x^{(1)}$ dominates another solution $x^{(2)}$ in a MOOP?

c) Consider two different objective spaces of two-objective optimization problems as shown in Figures 2(i) and (ii) and the mapping of 11 solutions numbered '1', '2', …, '11' to these spaces. Which solutions can be regarded as the pareto-optimal solutions in the two sub-figures? Explain your answer.

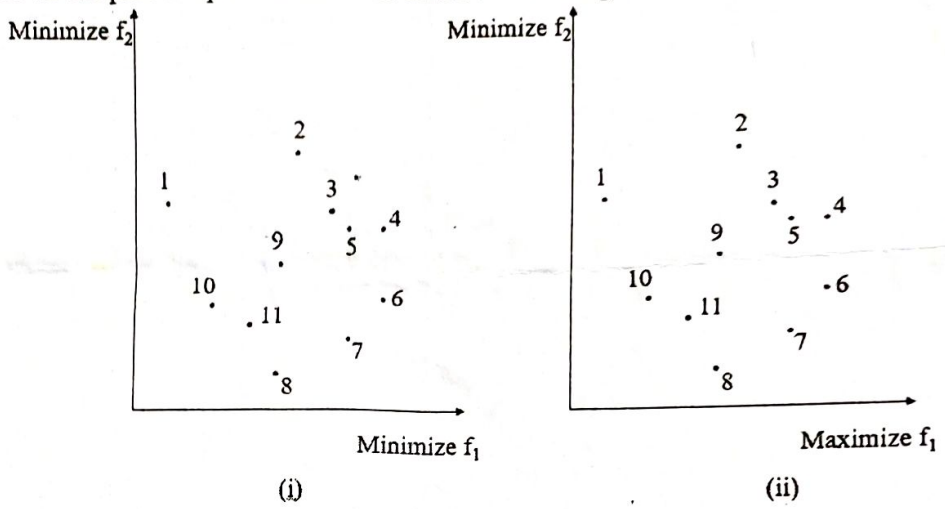


Figure 2: Objective spaces and mapping of solutions to these spaces **[2+2+4 = 8 marks]**

Q5. a) Write the important differences between pareto-based and non-pareto-based multi-objective optimization techniques.

b) Describe Lexicographic Ordering technique to solve MOOP.

c) Explain the working of the Lexicographic Ordering algorithm with the help of the following MOOP having three objectives f_1, f_2, f_3 involving three variables X_1, X_2, and X_3, where $\mathbf{f_1 \prec f_3 \prec f_2}$. The symbol '$\prec$' indicates '*ranked higher than*'.

$$\text{Minimize } f_1 = 1 + X_1^2$$
$$\text{Maximize } f_2 = X_3 - X_2$$
$$\text{Minimize } f_3 = X_3 - X_1$$
$$0 \le X_1 \le 1,\ -2 \le X_2 \le 2,\ 5 \le X_3 \le 100$$

[2+4+6 = 12 marks]

Q6. a) Draw the architecture of a multi-layer perceptron with a single hidden layer.

b) Derive the weight update expressions for:

(i) each pair of neurons between hidden and output layer

(ii) each pair of neurons between input and hidden layer

[Define each symbol used and show all the steps for the above derivation clearly.] **[4+5+5 = 14 marks]**