# Indian Institute of Technology Kharagpur

## Department of Mechanical Engineering

**Instructions:** Answer all the questions. Each question carries two marks. There is no negative marking for wrong answer. There is no part marking for the questions.

First Test (2020-2021); Date: 24.09.2020; Total Marks: 20

Subject: ME60353: Knowledge-based Systems in Engineering; Maximum Time: 1 hour

| Name: | Roll No. |
|---|---|
| | |

Q 1. Let us consider a function y = f(x) = $x^4$ .

At the point x = x* = 0, it has the

(a) Maximum point
(b) Minimum point
(c) Saddle/inflection point
(d) None of the above

Answer:

Q 2. To minimize $y = f(x_1, x_2) = x_1^2 + x_2^2 + x_1 + x_2$ in the range of $-7.0 \leq x_1, x_2 \leq 7.0$ using Steepest Descent method, let us start with an initial solution $X_1 = \begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix} = \begin{Bmatrix} 0.0 \\ 0.0 \end{Bmatrix}$. In the first iteration, the search direction and optimal step length are seen to be as follows:

$$(a) \begin{Bmatrix} 1 \\ 1 \end{Bmatrix} \ and \ \lambda_1^* = \frac{1}{3}$$

$$(b) \begin{Bmatrix} 1 \\ 1 \end{Bmatrix} \ and \ \lambda_1^* = \frac{1}{4}$$

$$(c) \begin{Bmatrix} -1 \\ 1 \end{Bmatrix} \ and \ \lambda_1^* = \frac{1}{5}$$

$$(d) \begin{Bmatrix} -1 \\ -1 \end{Bmatrix} \ and \ \lambda_1^* = \frac{1}{2}$$

Answer:

Q 3. To solve an optimization problem involving two real variables: $x_1$ and $x_2$ varying in the ranges of (0.1, 20.5) and (0.2, 40.8), respectively, a binary-coded genetic algorithm is to be used. One of the GA-strings contained in the initial population of solutions is as follows:

$$\underbrace{101010}_{x_1}\ \underbrace{100110}_{x_2}$$

The first six bits counted from the left represent $x_1$ and $x_2$ is represented by the remaining six bits. Their real values are approximately found to be as follows:

(a) 10.5, 35.61
(b) 5.5, 21.78
(c) 13.7, 24.69
(d) 16.5, 28.89

Answer:

Q 4. Let us try to solve a maximization problem of the form: $= f(x_1, x_2) = x_1 x_2$ , where $x_1$ and $x_2$ are two real variables lying in the range of (5.0, 20.0). Use a binary-coded GA to solve this maximization problem. Its initial population of size N = 4 created at random is given below. Let us use 4 bits to represent each of the variables.

1010 0101
1001 0110
0111 1110
1101 1011

Using Ranking selection, their probability values of being selected in the mating pool are found to be as follows:

(a) 0.2, 0.1, 0.4, 0.3
(b) 0.3, 0.4, 0.1, 0.2
© 0.1, 0.2, 0.3, 0.4
(d) 0.4, 0.1, 0.2, 0.3

Answer:

Q 5. Let us consider a schema, H: *1*****0** of a binary-coded GA. Its probability of destruction due to bit-wise mutation of probability $p_m$ = 0.01 is determined as

(a) 0.02

(b) 0.85
(c) 0.45
(d) 0.60

Answer:

Q 6. Let us consider two parents participating in two-point crossover of a binary-coded GA as given below:

Pr1: 111000111000 11100011

Pr2: 101010110011 00111010

crossover sites

Crossover sites are selected at random, as given above. Children solutions are found to be as follows:

(a) 11100011001111100011

10101011100000111010

(b) 10101110110011000110

01010101011010101010

(c) 11100001110100111000

10101111000110110011

(d) 01110001110011100011

01100111010100111010

Answer:

Q 7. To solve an optimization problem using a real-coded genetic algorithm (RCGA), let us consider two parents as follows:

$$\mathrm{Pr}_1 = 20.65$$
$$\mathrm{Pr}_2 = 10.84$$

The children solutions are to be calculated using Simulated Binary Crossover (SBX) by assuming the probability distributions for the contracting and expanding zones as follows:

$$C(\alpha) = 0.5(\mathrm{q}+1)\alpha^{q}$$
$$\mathrm{Ex}(\alpha) = 0.5(\mathrm{q}+1)\frac{1}{\alpha^{(q+2)}} \quad ,$$

where α represents the spread factor and take the exponent q=4. By assuming the random number r =0.6, the children solutions are approximately calculated as follows:

(a) 8.540, 21.653
(b) 8.834, 20.893
(c) 10.616, 20.874
(d) 7.834, 21.874

Answer:

Q 8. Let us consider a constrained optimization problem as given below

$$\text{Minimize} \quad y = f(x_1,x_2) = 3x_1 - 2x_2 + x_1x_2$$

$$\text{subject to} \quad 2x_1 + x_2 < 6.0$$

$$x_1^2 + x_2^2 - x_1x_2 > 10.0$$

$$\text{and} \quad 0.5 \le x_1,x_2 \le 8.0$$

Let us try to solve this constrained optimization problem using the concept of dynamic penalty. Take $x_1$=2.0, $x_2$=4.0. Assume the constants C =8.0, α = 2, β = 3.

Penalty term is found to be equal to

(a) 512
(b) 820
(c) 930
(d) 1026

Answer:

Q 9. In comparison with Sammon's non-linear mapping, VISOR algorithm of mapping is computationally

(a) slower
(b) faster

(c) equivalent
(d) not comparable

Answer:

Q10. Pareto-front of optimal solutions is named so,

(a) as there exist a large number of optimal solutions lying on this front

(b) as each optimal solution corresponds to a set of weights put on different objectives

(c) according to the name of Vilfredo Pareto

(d) as it can be obtained for different pairs of objectives

Answer:

ANSWER KEYS

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|---|---|---|---|---|
| Q. 1: | Q. 2: | Q. 3: | Q. 4: | Q. 5: |
| Q. 6: | Q. 7: | Q. 8: | Q. 9: | Q. 10: |

Name: Roll No.