Department of Industrial Engineering
University of Stellenbosch

Simulasie 442 : Simulation 442
2025

MEMORANDUM

Tutoriaal 8 *Tutorial 8*	Punt: 58 *Mark:*	Ingeedatum: **26-09-2025** (10:00) B3003 *Due date:*

Instruksies:	Formatteer alle syfers sinvol. Werk in groepe van twee. Toon beide lede se name op een dokument aan asb. Gebruik Matlab, R of Excel vir u berekenings. Die data vir hierdie tutoriaal is beskikbaar in die lêer Tut08_2025_RawData.xlsx. U mag nie oplossings met ander groepe uitruil nie.
Instructions:	*Format all numbers sensibly.* *Work in groups of two.* *Indicate both names on one submission please.* *Use Matlab, R or Excel for your calculations.* The data for this tutorial is available in the file Tut08_2025_RawData.xlsx. *You may not exchange solutions with other groups.*

Question 1 [20]

Refer to the *Basic Genetic Algorithm* (Algorithm 1) of the eBook and consider the objective function provided below. We want to find an integer value that maximises the function. The current population of chromosomes as well as their fitness values are provided in the data set labelled 'Question 1'. We shall now go through one iteration of the Genetic Algorithm.

$$\text{Maximise } f(x) = 6x^4 - 25x^3 + 13x^2 - 23x + 162$$

subject to $0 \leq x \leq 27$.

Use the information provided above to answer the following questions.

(a) Let's assume that the cross-over probability has been satisfied. Two random numbers were sampled as 0.080 and 0.920, which have to be used to randomly select the two parent chromosomes. Find two indices using the random numbers given to select two parent chromosomes.

[4]

(b) Now that the parent chromosomes have been selected, the cross-over function must be performed. The cross-over point was randomly determined to be between the second gene. Perform the cross-over function and provide the binary encoding, x values and fitness values of the child chromosomes.

[6]

(c) Now that the child chromosomes have been determined, you must select the child with the best fitness value and perform the mutation function. Take $P(\text{Mutation}) = 0.05$ and determine the binary encoding of the child chromosome as well as its fitness value after applying the mutation function to each gene in the chromosome using

	Genes				
	1	2	3	4	5
U	0.950	0.065	0.027	0.623	0.057

[4]

(d) The last step is to replace the least fit chromosome in the population with the mutated child chromosome. Find and replace the least fit member in the population, and show that the average fitness of the population has increased.

[6]

(a) We select the two chromosomes by using the two random numbers that was sampled. We determine the chromosomes by using:
Parent 1 = 1 + INT(0.0.080(10)) = Chromosome 1 ✓✓
Parent 2 = 1 + INT(0.920(10)) = Chromosome 10 ✓✓

b)

	Encoding	x value	Fitness value
Parent 1:	01**101**	13	118501
Parent 2:	10**001**	17	381829

		Chromosome	x value	Fitness value
Option 1	**Child 1:**	10**101**	21	940773
	Child 2:	01**001**	9	22149

or

		Chromosome	x value	Fitness value
Option 2	**Child 1:**	**001**01	5	997
	Child 2:	**101**10	22	1145284

c) **Option 1**

Child 1 is the best child as its fitness value is the largest (i.e. 940 773)

	Genes				
	1	2	3	4	5
U	0,950	0,065	0,027	0,623	0,057
Test	>0.05	>0.05	**Mutation**	>0.05	>0.05
Child 1	1	0	1	0	1
New Child 1	1	0	0	0	1

	Encoding	x value	Fitness value
New Child 1	10001	17	381829

or

Option 2

Child 2 is the best child as its fitness value is the largest (i.e. 1 145 284)

	Encoding	x value	Fitness value
New Child 2	10010	18	488016

Figure 1: Question 1b & 1c Memo

Option 1

d) The current population is

Chromosome Number	Encoding	x value	Fitness value
1	01101	13	118501
2	11000	24	1652154
3	01000	8	12586
4	01111	15	222117
5	11101	29	3644389
6	10001	17	381829
7	01011	11	56053
8	00110	6	2868
9	01001	9	22149
10	01110	14	164284
		Average fitness of population	**627693**

Least fit member (chromosome 8)

New population after the mutated child was substituted in

Chromosome Number	Encoding	x value	Fitness value
1	01101	13	118501
2	11000	24	1652154
3	01000	8	12586
4	01111	15	222117
5	11101	29	3644389
6	10001	17	381829
7	01011	11	56053
8	10001	17	381829
9	01001	9	22149
10	01110	14	164284
		Average fitness of population	**665589,1**

Figure 2: Question 1d Memo Option 1

Option 2

The current population is

Chromosome Number	Encoding	x value	Fitness value
1	01101	13	118501
2	11000	24	1652154
3	01000	8	12586
4	01111	15	222117
5	11101	29	3644389
6	10001	17	381829
7	01011	11	56053
8	00110	6	2868
9	01001	9	22149
10	01110	14	164284
		Average fitness of population	**627693**

Least fit member (chromosome 8)

or

Chromosome Number	Encoding	x value	Fitness value
1	01010	10	923
2	01000	8	-1621
3	01001	9	-813
4	01011	11	3929
5	01111	15	37173
6	00001	1	59
7	11010	26	580859
8	10010	18	99339
9	00110	6	-1581
10	10011	19	130577
		Average fitness of population	**84884,4**

Figure 3: EQuestion 1d Memo Option 2

Mark with the students' work from previous questions. Award 3 marks for showing the old population's least fit member and average fitness, and 3 marks for replacing the least fit member and calculating the new fitness of the population.

Question 2 [11]

Refer to (6.13) on p. 98 of the eBook and the (r, Q) inventory problem explained in class. Formulate the scenario below in terms of objective functions ($f_i(\mathbf{x})$, and list the elements represented by ξ.

The objective of an internet service provider with several data centres is to maximise network uptime for its users while at the same time minimising the cost of data transmission between centres as well as the cost of maintaining backup servers at each location. Factors that influence uptime (measured as a percentage) include the availability of bandwidth and unexpected equipment failures.
The transmission costs typically vary between R800 million – R2.5 billion annually, while the backup server maintenance costs vary between R200 million – R1.7 billion annually.

Max $f_1(\mathbf{x})$, network uptime, ✓✓or Min $f_1(\mathbf{x})$, network downtime,
Min $f_2(\mathbf{x})$, the transmission cost, and ✓✓
Min $f_3(\mathbf{x})$, the backup server cost, ✓✓

subject to
$x_1 \in \{0, 100\}$✓, $x_2 \in \{800m, 2.5b\}$✓ and $x_3 \in \{200m, 1.7b\}$. ✓

ξ is defined by the

1. the availability of bandwidth, and ✓
2. the breakdown of network hardware. ✓

Question 3 [10]

In a linear production line that manufactures fixed-dimension wooden floor boards, there are multiple components. The production line consists of a cutting machine, a sanding machine, and a staining machine, in this order.

1. How many physical buffers are there?

[2]

2. How many possible buffer allocations exist if we allow a maximum of two niches?

[2]

3. Show all the possible buffer-allocations for the previous subquestion.

[6]

1. 2 ✓✓
2. How many possible buffer allocations exist?

$$c = \binom{m+n-2}{m-2}$$
$$c = \binom{3+2-2}{1}$$

Thus, c = 3 ✓✓

3. Show all the possible buffer-allocations.

[6]

Combinations	**M1**	**Buffer_12**	**M2**	**Buffer_23**	**M3**
1		1		1	
2		2		0	
3		0		2	

Question 4 [3]

Refer to the previous question. If four buffer spaces are allowed *per buffer*, what is the total number of buffers spaces that can be allocated?
$n^{(m-1)} = 4^2 = 16$ ✓✓✓

Question 5 [8]

Consider the following two objectives.

$$\text{Minimise } f_1(x) = (x-2)^2$$
$$\text{Minimise } f_2(x) = (x+8)^{1.8}$$

subject to $0 \le x \le 15$.

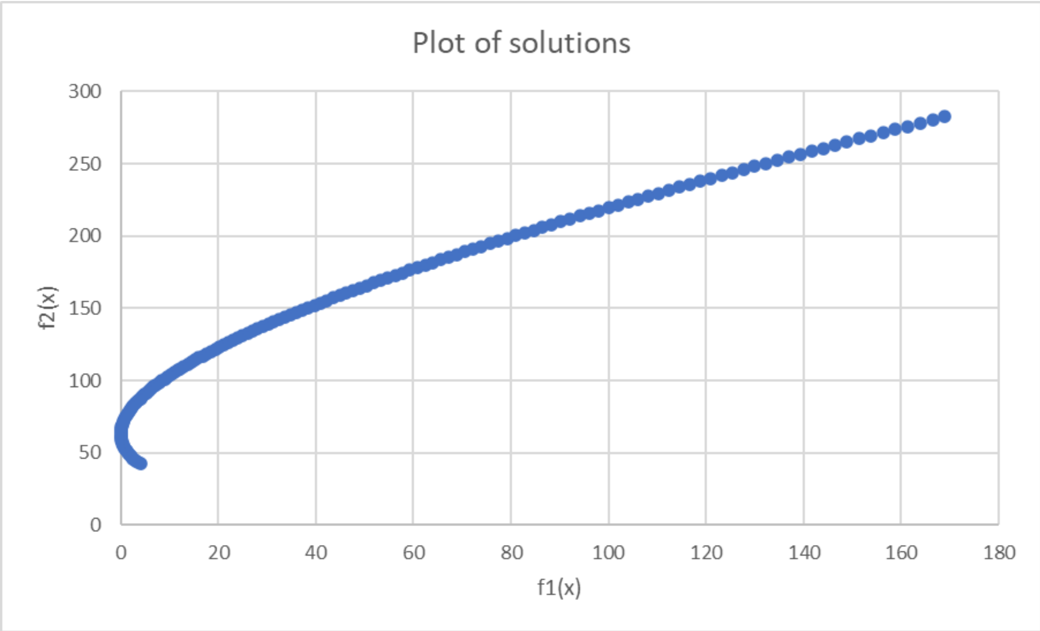
1. Plot the objective functions.

[4]

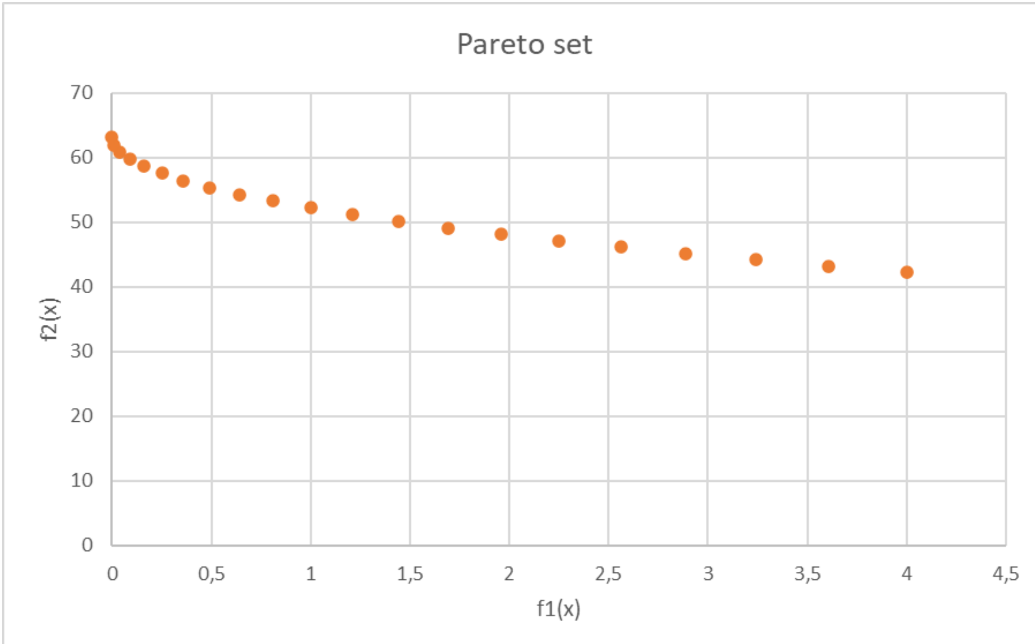
2. Find the Pareto solutions and plot the Pareto front.

[4]

1. Lable $f_1(x)$ and $f_2(x)$, ✓✓, shape is correct ✓✓



2. Lable $f_1(x)$ and $f_2(x)$, ✓✓, shape is correct ✓✓



Question 6 [2]

Suppose you have a population size of 40 chromosomes/solutions, 20 generations, and n = 10 replications per solution. Determine the total number of replications the TPS simulation optimiser will execute.

$$\begin{aligned} N_T &= [40(2 \times 20–1)] \times 10 \\ &= 15\,600 \text{ replications} \checkmark\checkmark \end{aligned}$$

Total: Cross-check: 54