Department of Industrial Engineering
University of Stellenbosch

Simulasie 442 : Simulation 442
2025

MEMORANDUM

Tutoriaal 7 *Tutorial 7*	Punt: **48** *Mark:*	Ingeedatum: **19-9-2025** (10:00) B3003 *Due date:*

Instruksies:	Formatteer alle syfers sinvol. Werk in groepe van twee en 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 Tut07_2025_RawData.xlsx. U mag nie oplossings met ander groepe uitruil nie.
Instructions:	*Format all numbers sensibly.* *Work in groups of two and 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 Tut07_2025_RawData.xlsx. *You may not exchange solutions with other groups.*

Question 1 [6]

1. Describe the evaluation process in the K-N procedure. How does this approach differ from traditional methods like ANOVA, and what are its benefits in scenario evaluation? [3]
2. What is the *indifference zone* δ in the K-N procedure? How does it affect the evaluation of scenarios and the overall decision-making process? [3]

1. The K-N procedure involves assessing scenarios sequentially, with decisions made at the end of each replication (after an initial n_0 replications) based on accumulated data. This approach allows for early elimination of less promising scenarios, leading to increased computational efficiency and the ability to correctly select the best scenario with high probability as more observations are made. ✓✓✓
2. The indifference zone in the K-N procedure sets the range where differences between scenarios are **considered negligible** by the simulation analyst (and possibly stakeholders). It helps focus on meaningful distinctions and reduces the number of replications for detailed comparison. It ensures that only scenarios with significant differences are considered, enhancing the computational efficiency of the selection process. ✓✓✓

Question 2 [14]

There are two sets of variables with multiple observations, as shown in the Sim442 RawData Excel sheet in Question2. Determine if the two variables are statistically significantly different from each other with a mean difference of 0 by deriving a hypothesis, conducting the t-test and calculating the p-value.
Note the sample have unknown, unequal variances (the variances were estimated from the samples), and the observations are normal distributed and independent.

Ho: The two variables V1 and V2 are not statistically significantly different

t-test by hand:

	V1	V2
n =	24	18
mean =	0,5189	0,4396
var =	0,0851	0,0644
std dev =	0,2918	0,2539
s^2/n =	0,0035	0,0036

α =	5%
v =	39,0449
t =	0,9386
t-cr =	2,0211

p-value =	0,3537

Thus, p-value is greater than α, so do not reject Ho.

Excel Data Analysis:

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	*Variable 2*
Mean	0,518855615	0,439620174
Variance	0,08513091	0,06444241
Observations	24	18
Hypothesized Mean Difference	0	
df	39	
t Stat	0,938551966	
P(T<=t) one-tail	0,1768687	
t Critical one-tail	1,684875122	
P(T<=t) two-tail	0,353737399	
t Critical two-tail	2,02269092	

Also accept: $0.35 < p < 0.4$

Question 3 [18]

McLaren Racing's technical directors have released an internal memorandum following the continuous poor performance of their vehicles due to engine reliability issues during the 2025 F1 season. The memorandum states that they have developed six new engine configurations, which would be tested over 20 replications (each) for the best lap times (in seconds) at their test track.

The recorded lap times of different configurations can be seen in the Sim442 RawData Excel sheet on sheet Question 4. *Assume that a shorter lap time will result in a reduced engine lifespan.*

Perform a t-test on data to determine which configurations are not statistically significantly different, and which configuration McLaren should select when considering the lap times and engine lifespan (the quickest lap time at the longest engine lifespan).

Hint: Provide the p-value table [9 marks] and interpret all the values [9 marks].

Per summary:

	Conf 2	**Conf 3**	**Conf 4**	**Conf 5**	**Conf 6**
Conf 1	0,0049302	0,02427004	0,00878175	0,00743689	0,35590437
Conf 2	-	0,57317651	0,938462822	0,710057	0,04480214
Conf 3		-	0,567899508	0,41796509	0,15638505
Conf 4			-	0,78265117	0,06209234
Conf 5				-	0,0471499

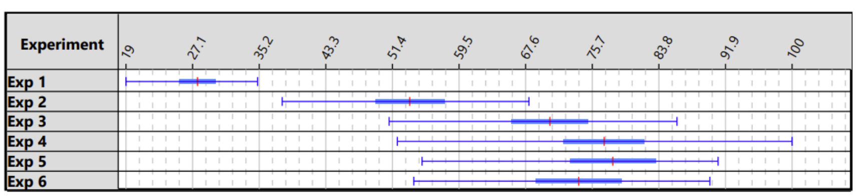
	Conf 2	**Conf 3**	**Conf 4**	**Conf 5**	**Conf 6**
Conf 1	diff	diff	diff	diff	same
Conf 2	-	same	same	same	diff
Conf 3		-	same	same	same
Conf 4			-	same	same
Conf 5				-	diff

Configuration	**Average**
1	110.561744
2	126.263885
3	123.5213274
4	126.6664929
5	128.4024832
6	115.8665158

- Configuration 1 is the best – yields the shortest lap time. ✓
- From the p-value summary table: Configuration 1 and Configuration 6 do not differ statistically significantly ✓, since the p-value is greater than 0.05.✓
- Thus, Configuration 1 and Configuration 6 perform similarly ✓, but Configuration 6 yields (by implication) a better engine lifespan. ✓
- Thus, choose Configuration 6 when considering both lap time and engine lifespan.✓
  From the leftover Configurations (2, 3, 4, and 5):
- Configuration 2 and Configuration 3, 4, and 5 do not differ statistically significantly ✓
- Configuration 3 and Configuration 4 and 5 do not differ statistically significantly ✓
- Configuration 4 and Configuration 5 do not differ statistically significantly ✓

Question 4 [10]

Refer to the output of the Model 0 simulation below. In this example, Experiment 1 has one cook, Experiment 2 has 2 cooks, and so forth.
You want to *maximise* the throughput. What is the best number of cooks to use if the arrival rate is 0.5 arrivals/minute? Explain your answer.



Detailed Results

Experiment	root.Drain.statnumout	Standard Deviation	Minimum	Maximum	Left interval bound	Right interval bound
Exp 1	27.7	4.7914397352823	19	35	25.4575371755511	29.9424628244489
Exp 2	53.5	8.9824390076591	38	68	49.2960891380451	57.7039108619549
Exp 3	70.55	9.92856061015255	51	86	65.9032905976865	75.1967094023135
Exp 4	77.15	10.4994987349021	52	100	72.2360833300287	82.0639166699713
Exp 5	78.2	11.1996240538408	55	91	72.9584145943428	83.4415854056572
Exp 6	74.05	11.1519410630474	54	90	68.8307309209837	79.2692690790163

Table of the p-values of the T-test of the output value 'root.Drain.statnumout'

	Exp 2	Exp 3	Exp 4	Exp 5	Exp 6
Exp 1	0	0	0	0	0
Exp 2		0	0	0	0
Exp 3			0.048	0.028	0.301
Exp 4				0.761	0.371
Exp 5					0.248

Experiment (Exp) 5 has the highest throughput of 78.2.
From the p-table, it can be said that Exp 5 is not statistically significantly different from Exp 4, since the p-value of 0.761 is larger than alpha =0.05. ✓✓✓
Therefore, Exp 4 performs similarly to Exp 5, but at a higher cost of hiring another employee. (Similar argument for Exp 4 and Exp 6)✓✓
From the p-table, it can be said that Exp 4 is statistically significantly different from Exp 1,2 and 3, since the p-value is smaller than alpha =0.05. ✓✓✓
Therefore, the best number of cooks to use for an arrival rate of 0.5 arrivals/minute is 4 cooks (Exp 4). ✓✓

Total: Cross-check: 48
