Department of Industrial Engineering
University of Stellenbosch

Simulasie 442 : Simulation 442
2025

MEMORANDUM

Tutoriaal 11 *Tutorial 11*	Punt: 70 *Mark:*	Ingeedatum: **17-10-2025** (10:00) B3003 *Due date:*

Instruksies:	Formatteer alle syfers sinvol. Ontwikkel die modelle individueel. U mag in groepe van **twee** of minder werk om die vrae te beantwoord. Handig slegs een dokument in. Gebruik Tecnomatix en Excel vir u berekenings. **Hierdie tutoriaal en prakties is verpligtend**. **Indien u nalaat om die vereistes betyds na te kom, sal u die module sak**.
Instructions:	*Format all numbers sensibly.* *Develop the models individually.* *You may work in groups of* ***two*** *or less when answering the questions.* *Submit one document only.* *Use Tecnomatix and Excel for your calculations.* ***This tutorial and practical are compulsory.*** ***You will fail the module if you do not comply with the requirements, on time.***

The trauma unit problem (TUP)

Question 1 [19]

Complete the table below to show your understanding of the model for the trauma unit problem.

State the:	Trauma Unit Model	
Essence of the problem	Dynamic model with a deterministic input variable types with discrete, random time increments. The main performance indicator is the time a patient spends in the system. Find minimum number of doctors and nurses. It imitates the operations of a real-world trauma unit.	[2]
Objective of the simulation	Minimum waiting times	[1]
Input variables	• Treatment time distribution (log-log, exp) • Patient interarrival time (negexp, mean=5) • Distances between CR rooms	[3]
Decision variables	• Number of doctors/nurses • Whether the extra CR is implemented	[2]
Output parameters	• Time spent in hospital	[1]
Assumptions made	• Doctors and nurses are homogeneous (perform the same) • Shift change does not affect operations • Sufficient staff available to run three shifts for the 24h study • Staff correctly assign patients to the correct category period.	[2]
Validation considerations	• Nurses and doctors must first return to rest room before they can be allocated to another consultation room. • Necessary number of required doctors and nurses must be present in consultation room before a patient can be helped.	[2]
/////		
Apply Shannon's world view:		
Entity	Patients	[1]
Attributes	Type of care needed	[1]
Resources	Doctors and nurses	[1]
Conditions	Based on category (A, B, C), it is decided how many nurses and doctors must be present before treatment starts.	[1]
Events	Patient arrives	[1]
System State	Number of patients waiting at reception, waiting times	[1]

Question 2 [17]

1. Describe this model based on Figure 1.3 in the Simulation e-book in terms of time dependency, variable types and time increments. [3]

2. Define simulation by using this model as an example. [4]

3. Explain to your cousin in grade 8 why this model can be considered a production line, and what the bottleneck is. [4]

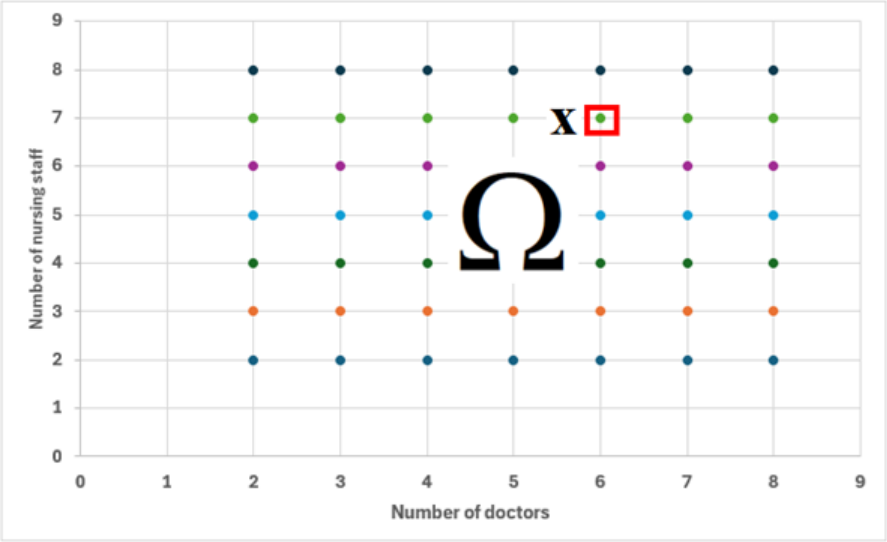
4. Refer to Section 6.6 in the eBook, and to (6.8). Explain what $\mathbf{x}$ and Ω in this problem are. [6]

1. It is a dynamic ✓model (time dependency) with deterministic input (number of docs for example) and stochastic input (service times for example)✓variable types with discrete, random ✓time increments.

2. It is the imitation ✓of the operations ✓of a real-world trauma unit ✓over a 24 hour period.✓

3. Entities (patients) flow into the system ✓and are worked on by resources (doctors), ✓once the operation is complete, the entities leave the system ✓. The bottleneck is the slowest part of the production line so in this case it would be (for example) CR2 because most patients need to go here but can't get serviced fast enough (accept other valid explanation) ✓

4. Ω is the combination of number of doctors and number of nursing staff allowed, *e.g.* $[1, 10]$✓✓✓ $\times$ $[1, 10]$, and the Boolean flags for CR4 installed or not, and which existing CR it supports, while $\mathbf{x}$ is any combination of these, *e.g.* $[4, 2]$. ✓✓✓



$f_1(x)$ = Patient turn-around time

$f_2(x)$ = Cost

Question 3 [34]

1. Determine the best number of doctors and nursing staff needed over the 24h period, as well as the need or not for the fourth consulting room (CR4). Should CR4 support CR1 or CR2? Explain and motivate your answer. [30]

2. Critically interpret the number of staff members calculated in the previous question with reference to real world labor laws. [4]

30 marks for the correct answer, 20 marks if a reasonable attempt was made to find the correct answer.
My experimental values and results are:

Experiment	root.NumDoctors	root.NumNurses	root.NewCR	root.CR1AndCR4	root.AvgTimeinSys	root.Throughput
Exp 01	3	4	false	false	3:08:02.4226	204.93
Exp 02	3	4	true	false	3:44:09.1332	204.65
Exp 03	3	4	true	true	3:31:08.8801	202.66
Exp 04	3	5	false	false	3:09:02.6259	204.41
Exp 05	3	5	true	false	1:53:11.1953	218.65
Exp 06	3	5	true	true	3:33:18.9005	201.74
Exp 07	4	5	false	false	2:31:45.5136	217.7
Exp 08	4	5	true	false	2:03:15.4217	221.3
Exp 09	4	5	true	true	2:37:48.8617	197.96
Exp 10	4	6	false	false	2:31:45.5136	217.7
Exp 11	4	6	true	false	1:09:06.7942	231.32
Exp 12	4	6	true	true	2:37:44.3856	197.94
Exp 13	5	6	false	false	2:31:45.5136	217.7
Exp 14	5	6	true	false	1:09:14.8857	231.31
Exp 15	5	6	true	true	1:52:03.0813	223.86
Exp 16	5	7	false	false	2:31:45.5136	217.7
Exp 17	5	7	true	false	1:04:22.1805	232.39
Exp 18	5	7	true	true	1:52:18.6606	223.75
Exp 19	6	7	false	false	2:31:45.5136	217.7
Exp 20	6	7	true	false	1:04:22.1805	232.39
Exp 21	6	7	true	true	1:40:40.6471	228.07
Exp 22	6	8	false	false	2:31:45.5136	217.7
Exp 23	6	8	true	false	1:04:22.1805	232.39
Exp 24	6	8	true	true	1:40:40.6471	228.07

1. Experiment 23 is the best option to select based on the lowest average time in the system of 1hr 4min 22s. It has 6 Doctors and 8 Nurses while a new CR is acquired (NewCR = TRUE), and this consulting room must take the same patients as CR2 (CR1AndCR4 = FALSE).
   Statistically, it is significantly similar to experiment 20 and experiment 17 with almost exact average time in system values. Experiment 20 has 6 doctors and 7 nurses with a new CR acquired and this consulting room must take the same patients as CR2.
   Experiment 17 has **5 doctors and 7 nurses and this consulting room must take the same patients as CR2**. So I would go for Experiment 17 in order to save the cost of 1 doctor and 1 nurse.

2. Critically interpret the number of staff members calculated in the previous question with reference to real world labor laws.
   [4]
   The personnel work shifts. There are laws governing the frequency of night shifts and the number of hours a person can work per week, and the number of days a person must be off between alternating day and night shifts. If one should schedule these personnel, one might need more personnel than reported by the simulation model.

Total: Cross-check: 70