



**NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY**

**FACULTY OF ENGINEERING**

**DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING**

**Master of Engineering in Manufacturing Systems and Operations Management**

**Modelling and Simulation**

**TIE 6210**

**Stage 1 Special Supplementary Examination Paper**

**March 2025**

This examination paper consists of 4 pages

**Time Allowed: 3 hours**

**Total Marks: 100**

**Special Requirements: Statistical Tables and Graph Paper**

**Examiner's Name: S Mhlanga**

**INSTRUCTIONS**

1. Answer any four **(4)** questions
2. Each carry 25 marks.
3. Use of calculators is permissible

## SECTION A

### Question 1

- a) "One stop shop for business investment in Zimbabwe", says the new Chairman for Zimbabwe Investment Authority in an interview. Formulation a problem from the Operations Manager view, on how you can answer to this statement. [5]
- b) Briefly discuss the issues to be considered in second stage of modelling and simulation. [5]
- c) A telephone in a police precinct is used for both emergency calls and personal calls. Personal calls are on a first-come, first served basis, and are made at a rate of one every  $5 \pm 1$  minutes. Emergency calls have priority and can preempt other calls. They arrive at a rate of one every  $15 \pm 5$  minutes. Emergency calls take  $3 \pm 1$  minutes to complete while personal calls take  $2 \pm 2$  minutes. Twenty percent of the people using the phone on a nonemergency basis wish to make another call as soon as possible, but they are given the lowest priority for their second call. Simulate until 200 calls of all types have been completed. Estimate the phone utilization. Draw the block diagram of the conceptual model for the system explained above. [15]

### Question 2

- a) Briefly explain some of the departures from ideal randomness. [10]
- b) Consider the 50 two digits numbers shown in Table 2.1 and determine whether there is an excessive number of runs up or down the mean using  $\alpha=0.05$ . [15]

Table 2.1: Random Numbers

0.37	0.54	0.51	0.01	0.81	0.69	0.28	0.34	0.49	0.75
0.99	0.99	0.17	0.46	0.05	0.10	0.66	0.42	0.49	0.18
0.06	0.84	0.39	0.24	0.40	0.40	0.64	0.19	0.62	0.79
0.72	0.56	0.43	0.97	0.30	0.96	0.94	0.58	0.05	0.73
0.18	0.97	0.26	0.88	0.64	0.60	0.47	0.11	0.78	0.29

### Question 3

- a) Briefly discuss the role of input distribution. [6]
- b) Explain the term sensitivity estimation. [4]
- c) Using the data shown in Table 3.1 formulated the input model and calculated its parameters. [15]

Table 3.1: Random Numbers

0.51	0.37	0.54	0.81	0.01	0.28	0.34	0.69	0.75	0.49
0.43	0.72	0.56	0.30	0.97	0.94	0.58	0.96	0.73	0.05
0.17	0.99	0.99	0.05	0.46	0.66	0.42	0.10	0.18	0.49
0.39	0.06	0.84	0.40	0.24	0.64	0.19	0.40	0.79	0.62
0.26	0.18	0.97	0.64	0.88	0.47	0.11	0.60	0.29	0.78

**Question 4**

- a) What is validation in simulation and why is it important? [5]  
 b) Briefly explain first order stationary in output analysis. [5]

c) For a Poisson distribution with probability mass function given by  $f(x) = \frac{e^{-\alpha} \alpha^x}{x!}$   $x=0, 1, \dots$

- i) State the two properties of a cumulative density function (cdf) [5]  
 ii) Find the cdf of the Poisson distribution  $F(x)$  [5]  
 iii) Find the mean for the pdf of the Poisson distribution [5]

**Question 5**

- a) Briefly explain five input features and their descriptors to be considered on software selection. [5]  
 b) Briefly explain five processing features and their descriptors to be considered on software selection. [5]  
 c) Consider the 30 two digits shown in Table 5.1 and determine whether there is an excessive number of runs above or below the mean using  $\alpha=0.05$ . [15]

Table 4.1: Random Numbers

0.19	0.02	0.39	0.37	0.2	0.8
0.77	0.54	0.58	0.37	0.66	0.45
0.38	0.65	0.04	0.15	0.91	0.48
0.7	0.69	0.05	0.34	0.81	0.85
0.53	0.32	0.39	0.47	0.63	0.98

**Question 6**

The telephone repair business is planning to open an emergency repair service at weekends. Calls requested come at random during the day and the time between calls follow the probability distribution given in Table 6.1. If the technician is free, he is sent immediately to carry out the repair at the customer’s premises. Otherwise, repairs are dealt with in the order that they are requested, when a technician becomes free.

Probability distribution of time to travel to a customer’s premises and repair times are given in Table 6.2, 6.3, below respectively. The technician is in radio contact with the base and jobs are issued to them over the radio.

Table 6.1 Inter call times

Time between Calls (mins)	10	15	20	25
Probability	0.1	0.2	0.4	0.3

Table 6.2 Inter Travel times

Travelling time (mins)	5	10	15	20	25	30
Probability	0.1	0.1	0.2	0.3	0.2	0.1

Table 6.3 Repair times

Repair Time (mins)	10	15	20	25
Probability	0.1	0.2	0.5	0.2

Table 6.4 Random Numbers corresponding to Table 6.1, 6.2 and 6.3

Time between Calls Random Numbers	21	21	24	3	89	16	35	51	61	67
Travel Time Random Numbers	32	28	45	5	36	75	15	71	7	69
Repair Time Random Numbers	96	69	36	17	25	68	13	64	94	64

- a) Simulate this system from the time that a call requesting service is made to the time when 10 repairs have been dealt with. Set out your results clearly on a table. [10]
- b) Use your result to estimate:
  - i) Average waiting per customer requiring services. [3]
  - ii) The proportion of time the technician is idle (not travelling or attending to repair) [3]
- c) Comment on the results of your simulation and at least two further performance measures that would be of interest to management. [9]