NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

Master of Engineering in Manufacturing Systems and Operations Management

Modelling and Simulation

TIE 6210

Main Examination Paper

September 2024

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 carries 25 marks.
3. Use of calculators is permissible

Question 1

a) "SADC Industrial Week 2026 will be held at ZITF", "Can we cope?", asked the MD for Chick-inn. Formulate a problem for modelling and simulation from this statement including the entities of concern and the parameters and performance measures that we need to keep in mind as we respond to the above statement. [10]

b) Parts arrive in the system exponentially with mean inter arrival time of 10 minutes. 40 % of the parts require processing at a milling center, 30% of them require processing at a drilling center and the remaining parts are to be processed on a lathe. After these machining process parts are sent to an inspection station followed by a dispatch center. There are two inspectors of the same kind. The milling center and drilling center undergoes an exponential failure with mean uptime of 300 minutes and down time of 45 minutes. The time taken at different centers is given in Table 1.1.

Table 1.1 Station process time

Station	Time taken in minutes
Milling	TRIA(12,15,18)
Drilling	UNIF(15,18)
Lathe	TRIA(10,12,16)
Inspection	TRIA(8,10,12)
Dispatch	UNIF(5,8)

Develop a conceptual model of the systems described above which will need to find the utilization and number in the queues at different points and concluded by the number that passed through the system. [15]

Question 2

a) Discuss briefly four (4) distinct approaches to the simulation of discrete event systems [10]

b) Using the 50 two digit random numbers shown in Table 2.1 apply the Run up and Runs Down test with $\alpha=0.05$ to determine if the hypothesis that the numbers are independent distributed on the interval [0, 1] can be rejected. [15]

Table 2.1: Random Numbers

0.55	0.15	0.35	0.86	0.21	0.84	0.3	0.85	0.22	0.47
0.32	0.61	0.15	0.67	0.26	0.81	0.3	0.29	0.85	0.09
0.96	0.87	0.3	0.32	0.21	0.83	0.75	0.95	0.01	0.27
0.09	0.8	0.76	0.97	0.68	0.14	0.07	0.9	0.29	0.79
0.49	0.34	0.92	0.22	0.65	0.74	0.92	0.15	0.02	0.26

Question 3

a) Discuss briefly two (2) methods of modelling of discrete event systems simulation.   [4]

a) Discuss briefly two (2) advantages of discrete event systems simulation.   [4]

c) Test for uniformity using Kolmogorov Smirnov method for numbers given in Table 3.1. (Using $\alpha=0.05$).   [17]

Table 3.1: Random Numbers

0.61	0.32	0.15	0.67	0.3	0.29	0.26	0.81	0.85	0.09
0.15	0.55	0.35	0.86	0.3	0.85	0.21	0.84	0.22	0.47
0.87	0.96	0.3	0.32	0.75	0.95	0.21	0.83	0.01	0.27
0.34	0.49	0.92	0.22	0.92	0.15	0.65	0.74	0.02	0.26
0.8	0.09	0.76	0.97	0.07	0.9	0.68	0.14	0.29	0.79

Question 4

a) Explain briefly three methods of validation.   [9]

b) Given the Time between calls in Table 4.1 and the corresponding Service Times and Probability in Table 4.2. May you give a recommendation for Smallcity Taxi considering idle time and number of customers having to wait as performance measures. Hint first simulate for one taxi for 20 calls and then simulate for two taxis for 20 calls.   [16]

Table 4.1: Time between calls

Time Between Calls	Probability		
15	0.14		
20	0.22		
25	0.43		
30	0.17		
35	0.04		

Table 4.2: Service Time

Service Time	Probability		
5	0.12		
15	0.35		
25	0.43		
35	0.06		
45	0.04		

Table 4.3: Random Numbers for Calls

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
79	95	45	89	53	60	74	64	39	18	64	57	55	64	62	95	22	44	11	

Table 4.4 Random Numbers for Service

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
35	57	78	14	32	71	53	40	93	15	97	23	6	69	85	97	90	79	86	76

Question 5

a) Discuss with example the purpose of input analyser within ARENA software [5]

b) Discuss with example the purpose of output analyser within ARENA software [5]

b) Mr Kapenta is very interested in determining the effect of unscheduled downtime of the flash freezing unit on shift output. Fin has implemented a data collection procedure that will track the status of the machine over a fourteen day period. Ten instances of downtime are recorded during this data collection period. The time between failures is given in Table 5.1.

   i) Hypothesize a distribution for this dataset. [5]

   ii) Identify the best fit parameter (s) for your hypothesis distribution. [10]

  In your answer describe why you feel this selected distribution is appropriate.

Table 5.1

Downtime Instance	1	2	3	4	5	6	7	8	9	10
MTBF (Days)	2.33	1.58	4.65	9.18	2.61	1.24	0.36	2.41	0.45	1.37

Question 6

a) Describe briefly the four world views to discrete event simulation. [12]

b) Considering the 50 digits shown in Table 6.1 and test whether the 2nd , 7th, 12th ...numbers in the sequence are autocorrelated, where $\alpha=0.05$? [13]

Table 6.1: Random Numbers

0.48	0.36	0.30	0.01	0.54	0.06	0.61	0.34	0.96	0.85
0.86	0.14	0.48	0.86	0.89	0.60	0.04	0.37	0.49	0.83
0.83	0.37	0.42	0.21	0.90	0.79	0.57	0.89	0.91	0.99
0.27	0.41	0.95	0.81	0.96	0.06	0.23	0.31	0.09	0.77
0.47	0.13	0.73	0.55	0.11	0.25	0.23	0.75	0.36	0.72

END OF EXAM