

FACULTY OF APPLIED SCIENCES
DEPARTMENT OF APPLIED MATHEMATICS
SIMULATION MODELLING

May 2003

Time : 3 hours

Candidates should attempt **ALL** questions from Section A and **ANY THREE** questions from Section B.

SECTION A

A1. Verification techniques in simulation include:

- (a) structured walk-through,
- (b) diagnostic simulation runs,
- (c) comparison to a well understood problem,
- (d) trace analysis

Discuss how you would use each of these methods, and how they ensure that your model correctly represents the system you are trying to simulate. [8]

A2. Discuss the methods that can be used when simulating a non-terminating system in steady-state, to ensure that the initial bias is eliminated and the data satisfies the assumption of independence. Which method do you consider to be the most effective and why? [12]

A3. Draw the flow diagram for the execution of a three phase simulation model. State the differences between a B and C activity. [5]

SECTION B

- B4. (a) Consider the simplest form of a game called *craps*. In this game, a pair of dice is rolled. If on the first throw a 7 or 11 is rolled, a win is right away. If instead, a 2,3 or 12 is rolled, we lose right away. Any other total gives the player a second chance. In this part of the game, the player continues rolling the dice until he gets a 7 or the total of his first throw. If he gets a 7, he loses. If the player rolls the same total as his first throw, he wins. Assuming the dice is fair, develop an experiment to determine the percentage of the time the player wins. [12]
- (b) A job shop manager wishes to develop a simulation model in order to help schedule jobs through the shop. He has evaluated the completion times for all the different types of jobs. For one particular job, the times to completion can be represented by the following triangular distribution:

$$f(x) = \begin{cases} \frac{x}{8} - \frac{1}{4} & 2 \leq x \leq 4 \\ \frac{10}{24} - \frac{x}{24} & 4 \leq x \leq 10 \end{cases}$$

Develop a process generator for the distribution using the inverse transformation method and the acceptance-rejection method. [7,6]

- B5. A crash repair garage in Bulawayo has a single telephone line. If a call is received when the line is busy the caller is sent a message informing them that they are in a telephone queue, and soothing music is played down the telephone until the call can be answered. During weekdays the gaps between successive calls can be approximately described by an exponential distribution of the form:

$$f(t) = 0.2e^{-0.2t}, \text{ where } t \text{ is time in minutes}$$

- (a) What is the mean gap between successive calls? [1]
- (b) What is the mean number of calls received in one hour? [2]
- (c) What is the median time gap between successive calls? [3]
- (d) Calculate the probabilities of gap between calls given the following information:

Gap between successive calls (minutes)	Observed Frequency
0 - 2	80
2 - 4	54
4 - 6	39
6 - 10	41
10 - 20	30
20 - 30	5
30 - 40	1

(e) Carry out an appropriate statistical test to check if the observed frequencies appear to come from the given distribution. [8]

(f) Records provided by the telephone company show that the durations of the telephone conversations can be described by the probability distribution given below:

Length of Conversation (mins)	Probability
0 - 2	0.32
2 - 4	0.38
6 - 10	0.20
10 - 15	0.10

Show how you would use random number mappings to simulate the time for the telephone conversation. [5]

B6. Mr Ozias Ncube's Hamburger Joint, ONHJ, specialises in soyabean burgers. However, soya-burgers are not the only commodity sold. Customers may also buy soft drinks, fishburgers, and other fast foods. Customers arrive according to the following interarrival rate distribution over the lunch period from 11:00 AM to 1:00 PM.

Time Between Arrivals(minutes)	Probability
3	0.30
5	0.20
6	0.15
8	0.20
10	0.15

People who want burgers for lunch usually arrive in groups. The following distribution of arrivals was determined using historical data:

Number of People	Probability
1	0.40
2	0.30
3	0.20
4	0.10

Each individual customer orders between none and two burgers according to the following distribution:

Burgers per person	Probability
0	0.20
1	0.65
2	0.15

Due to fluctuations in burger-eating per person, the average stay per person is a random variable given by the following distribution:

stay(mins)	Probability
10	0.10
15	0.40
20	0.30
25	0.20

If a group enters ONHJ, the time in the system for the group is determined by the longest length of stay for an individual in that group.

Using random number tables, choosing the column beginning with 50199, 02101, 62251 ..., simulate behaviour of ONHJ for a period of 2 hours. Determine answers to the following questions:

- (a) How many burgers would have to be made on average on an hourly basis? [12]
 (b) What is the expected stay in the dining area per group of people? [13]

- B7. (a) Suppose the NUST bookshop buys copies of the *Daily News* at 33 cents each from publishers of the paper, and sells them for 50 cents each. Newspapers not sold are sold as scrap for 5 cents each. Newspapers can be purchased in bundles of 10. There are three types of newdays: "good", "fair" and "poor" with probabilities of 0.35, 0.45 and 0.20 respectively. The distribution of papers demanded on each day is given in the table below. By simulating demand for 20 days, determine the optimal number of papers the bookshop should purchase. Assume that the initial demand is 70 papers.

Demand	40	50	60	70	80	90	100
good	0.03	0.05	0.15	0.20	0.35	0.15	0.07
fair	0.10	0.18	0.40	0.20	0.08	0.04	0.00
poor	0.44	0.22	0.16	0.12	0.06	0.00	0.00

[15]

- (b) Smalltown Taxi operates one vehicle during 9:00 a.m to 5:00 p.m period. Currently, consideration is being given to the addition of a second vehicle to the fleet. the demand for taxis follows this distribution:

Time between calls(mins)	15	20	25	30	35
Probability	0.14	0.22	0.43	0.17	0.04

The distribution of time to complete a service is as follows:

Service time(mins)	5	15	25	35	45
Probability	0.12	0.35	0.43	0.06	0.04

Simulate five individual days of the operation of the current system and the system with an additional taxicab. Compare the two systems with respect to the waiting times of the customers and any other measures that might shed light on the situation, and advice Smalltown Taxi. [10]

END OF QUESTION PAPER