NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF APPLIED MATHEMATICS

JULY 2001 SUPPLEMENTARY EXAMINATION

SMA 5274 SIMULATION MODELLING

July 2001 3 Hours

This paper contains two sections, A and B.
Answer **ALL** questions in Section A.
Answer **THREE** questions from Section B.
All questions in Section B carry equal marks.

Statistical tables have been provided, and silent calculators may be used.

SECTION A : Answer ALL questions. (25 Marks)

A1. Verification techniques in simulation include:
- structured walk-through;
- diagnostic simulation runs;
- comparison to a well understood problem;
- 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 Marks)

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

(12 Marks)

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

(5 Marks)

SECTION B : Answer THREE questions. (75 Marks)

B4. A crash repair garage in Bulawayo has a single telephone line. If a call is received when the line is busy the caller is given 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:

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

a) What is the mean time gap between successive calls?
(1 Mark)

b) What is the mean number of calls received in a one hour period?
(2 Marks)

c) What is the median time gap between successive calls?
(3 Marks)

d) Complete the table shown below, giving all probabilities to 3 decimal places.

Gap between successive calls (minutes)	**Probability**	**Observed Frequency**
0 to under 2 minutes	0.330	80
2 to under 4 minutes		54
4 to under 6 minutes		39
6 to under 10 minutes		41
10 to under 20 minutes		30
20 to under 30 minutes		5
30 to under 40 minutes		1

(6 Marks)

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

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

Length of Conversation (minutes)	**Probability**
0 to under 2 minutes	0.32
2 to under 6 minutes	0.38
6 to under 10 minutes	0.20
10 to under 15 minutes	0.10

Show how you would use random number mappings to simulate the time for the telephone conversation.
(5 Marks)

B5. A small radio and television repair business is planning to operate an emergency repair service at weekends. Calls requesting service come in at random during the day, the time between such calls following the probability distribution given in the table below. If a repairman 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 repairman becomes free.

Probability distributions for time to travel to customer's premises and repair times are given in the table below. It is intended to have two repairmen on duty at any time during the weekend. The repairmen are in radio contact with the base and jobs are issued to them over the radio.

Time between calls (mins)	10	15	20	25		
Probability	0.1	0.2	0.4	0.3		
Travelling time (mins)	5	10	15	20	25	30
Probability	0.1	0.1	0.2	0.3	0.2	0.1
Repair Time (mins)	10	15	20	25		
Probability	0.1	0.2	0.5	0.2		

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 in table form.

(16 Marks)

b) Use your results to estimate:
   i) the average wait per customer requesting service;
   ii) the proportion of time the repairmen are idle (i.e. not travelling or attending to a repair).

(4 Marks)

c) Comment on the results of your simulation and suggest at least <u>two</u> further performance measures that would be of interest to management.

(5 Marks)

Use the following random numbers for your simulation:

Time between request for service	1004009585
Travel time	4225264848
Repair time	4835043828

B8 continued

All patients coming into the A&E department have an initial assessment carried out by a specially trained nurse (a senior nurse), who reports on the nature and seriousness of the injuries (or diseases) and then classifies the patients according to the degree of urgency. This process is called "triage". Patients are classified into three groups, triage group 1 for emergency patients, triage group 2 for urgent patients and triage group 3 for ordinary patients. Triage is usually performed after a patient is booked in at the reception. But for an emergency patient whose life is at risk, triage is not performed until resuscitation is done.

The patient flow through the hospital for each of the triage groups is given below.

The major features of triage group 1 are:

- patients require resuscitation first;
- book-in, triage, consultation and any waiting all take place inside the resuscitation room;
- patients require a nurse to escort them throughout their visits;
- 40% of patients require a X-ray examination;
- 60% of them require a second consultation on the same day;
- all patients are admitted to a hospital bed;
- these patients have the highest priority.

The major features of triage group 2 are:

- patients are sent to a cubicle straight away on arrival;
- book-in, triage, consultation and any waiting all take place inside the cubicle;
- patients require a nurse to escort them throughout their visits;
- 66% of patients require a X-ray examination and then have a second consultation;
- about 50% are admitted to a hospital bed;
- these patients have a secondary priority to triage group 1.

The major features of triage group 3 are:

- almost all patients book-in at the reception and have their triage in the triage room;
- after triage, about 30% are sent to a cubicle waiting to be seen by a doctor; the rest wait in the waiting room and will be seen by a doctor in a consultation room;
- 46% of patients require an X-ray examination;
- 58% of patients require a second consultation on the same day;
- about 7% are admitted to a hospital bed;
- these patients have the lowest priority.

Create an activity cycle diagram for this situation.

(25 Marks)

END OF QUESTION PAPER

B6. There is a shuttle service between a hotel and a park provided by one minibus that can accommodate up to 10 passengers. The ride takes 26 minutes on average, with a standard deviation of 5 minutes, normally distributed. The bus waits until X passengers get in, where X is the smaller number of those passengers waiting and the maximum number of 10. After X passengers are in the bus, the bus starts immediately in the opposite direction and does not stop on the way. The time for one passenger to enter is 15 seconds. Only those people who took the shuttle service from the hotel can get on the bus at the park. The service opens at 9.00am and the last bus leaves the park at 5.00pm. Assume that the time between two hotel guests joining the queue waiting for the bus is exponentially distributed with an average of 9 minutes. There is a probability of 0.5 that a guest in the park might want to leave. Those remaining in the park after the last bus leaves return on their own.

Write the pseudo code to simulate this situation. Include details of the distributions, and statistics to determine the number of guests who use the service in each direction per day, and their average waiting time for the minibus.

(25 Marks)

B7. A reservoir receives rainwater during the rainy season (October through February) and supplies water during the whole year. If there are more than 1000 units in the reservoir, there is an overflow that destroys the nearby crops. When the quantity at the beginning of the month surpasses S units, the water flow is let into a river before the 1000 unit mark is reached to avoid an overflow. The water is let out until the level is reduced to s units. The reservoir manager wants to find the best value of S and s to maximise profits.

Write a project proposal for the simulation of this situation.

(25 Marks)

B8. An Accident and Emergency (A&E) Department of a local hospital is looking to improve its current performance. To do this, two immediate questions need to be answered:

- how to schedule and utilise the currently available staff in order to reduce patient waiting times and visit times (the total time a patient spends in the A&E department);
- how many extra staff are required, if necessary, to enable specified service standards to be achieved.