NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCE

DEPARTMENT OF APPLIED MATHEMATICS

Msc in Operation Research

Modelling and Simulation – SMA 5274

EXAMINATIONS December 2004

Time allowed: 3 hours

Instructions: ***Supply Statistical Tables and graph paper***
Answer 5 questions

Q1 a) Discuss briefly the steps involved in simulation study [12]

b) Discuss briefly the three major characteristics of queuing theory. [8]

Q2 a) A grocery till counter is modeled as a single server queue. The simulation will run until 1000 customers have been served. IN addition, assume that the interarrival times of customers are exponentially distributed with a mean of 4.5 minutes and that the service times are (approximately) normally distributed with a mean of 3.2 minutes and standard deviation of 0.6 minutes. When the cashier is busy, a queue forms with no customers turned away.

Write the **Model File program** and the **Experimental file program in SIMAN**. Given the model is to simulate the completion of 1000 customers, estimate mean number customers waiting in the queue and the till operator's utilization, the number of customers that have spent more than 4 minutes in the system. [20]

Q3 a) Briefly explain the following terms:

i) Attributes [2]
ii) Activity [2]
iii) Event [2]

b) Consider the following continuously operating job shop. Interarrival times of jobs are distributed as shown in Table 3.1.

Table 3.1: Interarrival times of jobs

Time Between Arrivals (Hours)	0	1	2	3
Probability	0.23	0.37	0.28	0.12

Given processing times for jobs are uniformly distributed with minimum of 47 minutes and maximum of 54 minutes. Construct a simulation table, and perform a simulation for 10 new customers. Assume that when the simulation begins there is one job being processed (scheduled to be completed in 25 minutes) and there is one job with a 50-minute processing time in the queue.

i) Develop the simulation table and analysis for 10 new customers. [8]
ii) What is the average time in the queue for the 10 new jobs? [2]
iii) What is the average processing time of the 10 new jobs? [2]

iv) What is the maximum time in the system for the 10 new jobs? [2]

Q4 a) Briefly discuss the Linear Congruential random number generation method. [8]
b) The sequence of numbers shown in Table 4.1 has been obtained from accidents on a highway. Use the Kolmogorov-Smirnov test with α=0.05 to determine if the hypothesis that the numbers are uniformly distributed can be rejected. [12]
Table 4.1; Records of 30 accidents involving an injury (the data represent the distance from a city.

88.3	40.7	36.3	27.3	36.8
91.7	67.3	7.0	45.2	23.3
98.8	90.1	17.2	23.7	97.4
32.4	87.8	69.8	62.6	99.7
20.6	73.1	21.6	6.0	45.3
76.6	73.2	27.3	87.6	87.2

Q5 a) What are the errors that can occur in random number generation? [8]
b) Considering the digits shown in Table 5.1 and based on runs up and runs down determine whether the hypothesis of independence can be rejected, where α=0.05 [12]

Table 5.1: Random Numbers

0.44	0.12	0.21	0.46	0.67
0.81	0.94	0.74	0.22	0.74
0.41	0.52	0.73	0.99	0.02
0.05	0.45	0.31	0.78	0.05
0.93	0.65	0.37	0.39	0.42
0.66	0.10	0.42	0.18	0.49
0.28	0.69	0.34	0.75	0.49
0.94	0.96	0.58	0.73	0.05
0.64	0.40	0.19	0.79	0.62
0.47	0.60	0.11	0.29	0.78

Q6 a) The following data represent the time to perform transactions in a bank, measured in minutes: 0.740, 1.28, 1.46, 2.36, 0.354, 0.750, 0.912, 4.44, 0.114, 3.08, 3.24, 1.10, 1.59, 1.47, 1.17, 1.27, 9.12, 11.5, 2.42, 1.77.
Develop an input model for this data. [10]

b) What is verification and what are the different ways to verify a model? [5]
c) Briefly discuss the terms terminating of simulation and length of replication. [5]

END OF EXAM

SIMAN Experimental Frame Elements

Operand	Description	Default
ATTRIBUTES: *Number, Name(1-D Array Index, 2-D Array Index), Initial Values,...:* repeats;		
Number	Attribute number (index into the A(k) array) -- integer	Sequential
Name	Attribute name (symbol name)	Blank
1-D Array Index	First dimension index into the named attribute array	No array
2-D Array Index	Second dimension index into the named attribute array	No array
Initial Values	Initial values upon entit creation (constant)	0.0 or last value
BEGIN: *Listing, Run Controller;*		
Listing	Option for generating a listing of experiment statements during experiment processing (Yes or No)	Yes
Run Controller	Invoke the Interactive Run Controller (Yes or No)	No
COUNTERS *Number, Name, Limit: Initialize Opeion, Output File:* repeats;		
Number	Counter number (integer)	Sequential
Name	Counter number and summary report identifier (symbol name)	"Counter Number"
Limit	Counter limit (positive integer)	Infinite
Initialize Option	Initialize counter between simulation replications (Yes, No, Replicate)	Replicate
Output File		
DSTATS: *Number, SIMAN Expression, Name, Output File:* repeats;		
Number	DSTAT number (integer)	Sequential
SIMAN Expression	SIMAN expression on which time-persistent statistics are to be recorded (expression)	--
Name	DSTAT name and label for the SIMAN summary reprot (symbol name)	Expression
Output File	Output file to which DSTATS observations are written during the simulation run (unique integer number or system-specific file name enclosed in double quotes)	No Save
EXPRESSIONS: *Number, Name(1-D Array Index, 2-D Array Index), Expressions:* repeats;		
Number	Expression number (integer)	Sequential
Name	Magnitude of counter increment (expression truncated to an integer	1
1-D Array Index	First dimension index into the named distribution array	No array
2-D Array Index	Second dimension index into the named distribution array	No array
Expressions	SIMAN *Expression*	--
PROJECT, *Title, Analyst Name, Date, Summary Report;*		
Title	Project title (alphanumeric)	Blank
Analyst Name	Analyst name (alphanumeric)	Blank
Date	Date in form or *month/day/year*	System specific
Summary Report	Create a summary report at the end of each replication (Yes or No)	Yes
QUEUES: *Number, Name, Ranking Criterion (Rule Expression):* repeats;		
Number	Queue number (integer)	Sequential
Name	Queue name (symbol name)	Blank
Ranking Criterion	Ranking criterion (FIFO, LIFO, HVF(Rule Expression), or LVF(Rule Expression))	FIFO
REPLICATE, *Number of Replications, Beginning Time, Replication Length, Initialize System, Initialize Statistics, Warm Up Period:* repeats;		
Number of Replications	Proceed priority (expression truncated to an integer)	1
Beginning Time	Initial setting of TNOW for each replication	0.0
Replication Length	Maximum length of each replication (constant)	Infinite
Initialize System	Initialize system status between replication (Yes or No)	Yess
Initialize Statistics	Discard previous observations between replications (Yes or NO)	Yes
Warm Up Period	Warm-up time for system to reach steady state conditions (constant)	0.0
RESOURCES, *Number, Name, Capacity:* repeats;		
Number	Resource number (optional)	Sequential
Name	Unique alphanumeric resource name	--
Capacity	Initial resource capacity	1
TALLIES: *Number ,Name, Output File:* repeats;		
Number	Tally number (integer)	Sequential
Name	Tally name and identifer for labeling summary report (symbol name)	"Tally *Number"*
Output File	Output unit or filename for saving observations (integer unit number, or system-specific file name enclosed in double quotes)	No save
VARIABLES, *Number, Name(1-D Array Index, 2-D Array Index), Values, ...:* repeats;		
Number	Variable number (integer)	Sequential
Name	Unique alphanumeric resource name	--
1-D Array Index	First index into the named variable array	No array
2-D Array Index	Second index into the named variable array	No array
Value	Initial values for variable at beginning of run (constant)	0.0 or last value