

NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCES

DEPARTMENT OF APPLIED MATHEMATICS

MASTERS OF SCIENCE – OPERATIONS MANAGEMENT

**Modelling and Simulation – SMA5274**

EXAMINATIONS DECEMBER 2005

*Time allowed: 3 hours*

*Instructions: Supply Statistical Tables and graph paper*

**Answer 5 questions**

Q1 a) Discuss briefly the steps involved in simulation study: [14]

b) Briefly discuss the following terms:

i) Model [2]

ii) Simulation [2]

c) Differentiate between a descriptive and prescriptive model. [2]

Q2 a) An office that dispenses automotive license plates has divided its customers into categories to level the office workload. Customers arrive and enter one of three lines based on their residence location. Model this arrival activity as three independent arrival streams using an exponential interarrival distribution with mean of 10 minutes for each stream. Each customer type is assigned a single clerk that processes the application forms and accepts payment. The service time is UNIF (8, 10) minutes for all three customer types. After completion of this step, all customers are sent to a second clerk who checks the forms and issues the plates. The service time for this activity is UNIF (2.66, 3.33) minutes for all customer types.

Write the **Model File program** and the **Experimental file program in SIMAN V** for the simulation to run for 5000 minutes to determine the number of customers that exit the system, and the utilization of the clerks. [20]

(Model Frame Blocks and Experimental Frame Elements are given in the Appendix)

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 and the random digits are given in Table 3.2.

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.

- 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]

Table 3.2: Random digits for Arrival and Service Times

Job New arrivals	1	2	3	4	5	6	7	8	9	10
Random Digits for Arrivals	-	63	38	80	42	56	89	18	51	71
Random Digits for service	759	248	500	635	012	603	757	973	807	714

- Q4 a) Briefly discuss the Linear Congruential random number generation method. [6]
- b) Use the linear congruential method to generate a sequence of three two-digit random integers assuming  $X_0 = 117$ ,  $a=8$ ,  $c=47$ , and  $m=100$ . [3]
- b) Considering the digits shown in Table 4.1 and based on runs up and runs down determine whether the hypothesis of independence can be rejected, where  $\alpha=0.05$  [11]

Table 4.1: 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

- Q5 a) Briefly discuss the three step approach in validation process giving examples in each step. [8]
- b) Considering the 40 digits shown in Table 5.1 and test whether the 2<sup>nd</sup>, 9<sup>th</sup>, 16<sup>th</sup> ... numbers in the sequence are autocorrelated, where  $\alpha=0.05$ ? [12]

Table 5.1: Random Numbers

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

- Q6 a) What are the errors that can occur in random number generation? [8]

b) The time (in minutes) between requests for the hookup of electric service was accurately maintained at SAZE Company with the following results for the last 50 requests shown in Table 6.1. How are the times between requests for service distributed? Develop a suitable model. [12]

Table 6.1: Time (in minutes) between requests

0.661	4.910	8.989	12.801	20.249
5.124	15.033	58.091	1.543	3.624
13.509	5.745	0.651	0.965	62.146
15.512	2.758	17.602	6.675	11.209
2.731	6.892	16.713	5.692	6.636
2.420	2.984	10.613	3.827	10.244
6.255	27.969	12.107	4.636	7.093
6.892	13.243	12.711	3.411	7.897
12.413	2.169	0.921	1.900	0.315
4.370	0.377	9.063	1.875	0.790

END OF EXAM

### SIMAN Model Frame Blocks

The following SIMAN model block definitions were extracted from "Introduction to Simulation Using SIMAN, Second Edition", by Pegden, Shannon, and Sadowski. The list is not inclusive and some block operands are not included if not applicable to TIE6210/SCS61\*\* projects. Students may copy the definitions to use as reference material during TIE6210/SCS61\*\* exams.

BLOCK FORMAT		
Operand	Description	Default
ALTER: Resource ID, Capacity Change: repeats;		
ASSIGN: Variable or Attribute = Value: repeats;		
BEGIN: Model Listing, Model Name;		
BRANCH: Max Number of Branches, Random Number Stream: Branch Type, Condition or Probability, Destination Label, Primary Entity Indicator;		
	Branch Types:	
		IF, Condition, Label, Primary Entity Indicator;
		WITH, Probability, Label, Primary Entity Indicator;
		ELSE, Label, Primary Entity Indicator;
		ALWAYS, Label, Primary Entity Indicator;
COUNT: Counter ID, Counter Increment;		
CREATE, Batch Size, First Creation Time: Interval, Max Batches;		
DELAY, Duration;		
DUPLICATE: Quantity to Duplicate, Duplicate Destination: repeats;		
ELSE;		
ELSEIF: Condition or Expression;		
ENDIF;		
ENDWHILE;		
FINDJ: Start of Range, End of Range: Search Condition;		
IF: Condition or Expression;		
Condition or Expression	Condition or expression to evaluate (logical or mathematical expression)	
INSERT: Queue ID, Rank to Place Entity;		
MATCH, Match Attribute: Queue Label, Destination Label: repeats;		
PICKQ, Queue Selection Rule, Balk Label: Queue Label: repeats;		
PROCEED, Priority: BlockageID: repeats;		
QUEUE, Queue ID, Capacity, Balk Label: Blockage Level, Blockage ID: repeats;		
RELEASE, Resource ID, Quantity to Release: repeats;		
REMOVE: Rank of Entity, Queue ID, Remove Entity Destination;		
SEARCH, Search Item, Starting Index, Ending Index: Search Condition;		
SEIZE, Priority: Resource ID, Number of Units: repeats;		
SELECT, Resource Selection Rule: Seize Label: repeats;		
TALLY: Tally ID, Value;		
WHILE: Condition or Expression;		

### SIMAN Experimental Frame Elements

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