

NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
FACULTY OF APPLIED SCIENCE
COMPUTER SCIENCE DEPARTMENT
DECEMBER EXAMINATIONS 2005

SUBJECT: SIMULATION AND MODELLING
CODE: SCS4108

INSTRUCTIONS TO CANDIDATES:

This Examination paper consists of **SEVEN (7)** questions
All questions carry equal marks
Answer **ANY FIVE (5)** questions

TIME: 3 HOURS

QUESTION ONE

- a) For pseudo-random number generators to be useful, they should produce sequences over $U[0,1)$ that are **uniform** and **independent**. Informally state what each of these properties means. Give and justify an example of a sequence that is uniform over $U[0,1)$ but not independent, and a sequence that appears to be independent but not uniform over $U[0,1)$. [10]

- b) A proposed random number generator produced the following sequence of values over $U[0,1)$:

0.3 0.8 0.1 0.9 0.5

Using the Kolmogorov-Smirnov test, determine whether or not this sequence is uniform over $U[0,1)$ with a level of significance of $\alpha = 0.05$. Be specific and show all work in the process. [10]

QUESTION TWO

- a) What is a model? What is the purpose of a model? [3]
b) Why do we build models (as opposed to experiment on actual systems)? [2]
c) Why is probability theory of interest to performance modeling of information systems? [1]
d) Distinguish between *deterministic* and *stochastic* models [4]

e) Consider the following single-server queuing system from time $t = 0$ to $t = 10$ sec. Arrivals and service times are:

- Customer #1 arrives at $t = 1$ and requires 3 seconds of service time
- Customer #2 arrives at $t = 3$ and requires 4 seconds of service time
- Customer #3 arrives at $t = 4$ and requires 8 seconds of service time

Solve for system throughput (X), total busy time (B), mean service time (T_s), utilization, (U), mean system time (W), and mean number in the system (L). You must show your work to receive credit. You must show the correct "units" (cust/sec, sec, etc.) to get full credit.

[10]

QUESTION THREE

- a) You are a consultant to an on-line "Web Mall" that uses ten Web servers. Every morning at 9:00am the ten servers are re-booted for the day's business. If one or more of the ten servers fail on boot-up, the mall cannot open for business until the failed server(s) are fixed. Assume that the probability of a server failing boot-up is 1% (or, on average 1 in 100 boot-ups fail). Your client wants to know the percentage of days that the Mall opens on time (i.e., that ten servers successfully boot-up). You may assume independence in server failures and you must show your work. [5]
- b) Briefly describe the characteristics of queuing systems. [10]
- c) Discuss one method of random number generation. [5]

QUESTION FOUR

- a) The sequence of numbers 0.54, 0.73, 0.98, 0.11 and 0.68 has been generated. Use the Kolmogorov-Smirnov test with $\alpha = 0.05$ to determine if the hypothesis that the numbers are uniformly distributed on the interval $[0,1]$ can be rejected. [10]
- b) Building a simulation model probably *is* a good idea but can also *not* be a good idea. Discuss this assertion giving examples [8]
- c) Discuss the advantages and disadvantages of 1) independent replications and 2) batch means method for run length control. [2]

QUESTION FIVE

- a) Use the chi-square test with $\alpha = 0.05$ to test whether the data shown below are uniformly distributed. In the test use 10 intervals of equal length, namely $[0, 0.1]$, $[0.1, 0.2]$, ..., $[0.9, 1.0]$. Given that $\chi^2_{0.05, 9} = 16.9$

0.34 0.90 0.25 0.89 0.87 0.44 0.12 0.21 0.46 0.67
 0.83 0.76 0.79 0.64 0.70 0.81 0.94 0.74 0.22 0.74
 0.96 0.99 0.77 0.67 0.56 0.41 0.52 0.73 0.99 0.02
 0.47 0.30 0.17 0.82 0.56 0.05 0.45 0.31 0.78 0.05
 0.79 0.71 0.23 0.19 0.82 0.93 0.65 0.37 0.39 0.42
 0.99 0.17 0.99 0.46 0.05 0.66 0.10 0.42 0.18 0.49
 0.37 0.51 0.54 0.01 0.81 0.28 0.69 0.34 0.75 0.49
 0.72 0.43 0.56 0.97 0.30 0.94 0.96 0.58 0.73 0.05
 0.06 0.39 0.84 0.24 0.40 0.64 0.40 0.19 0.79 0.62
 0.18 0.26 0.97 0.88 0.64 0.47 0.60 0.11 0.29 0.78

[14]

- b) Briefly discuss any two steps in a simulation study

[6]

QUESTION SIX

A small grocery has only one till. Customers arrive at the till at random from 1 to 10 minutes apart. The service distributions are shown in table 2.1. The random digits are given in table 2.2.

Table 2.1

Service Time (min)	1	2	3	4	5	6
Probability	0.05	0.1	0.2	0.3	0.25	0.10

Table 2.2

Customer	1	2	3	4	5	6	7	8	9	10
Random Digits for Arrival	-	26	98	90	26	42	74	80	68	22
Random Digits for Service	95	21	51	92	89	38	13	61	50	49

- i. Develop the simulation table and analysis for customers. [11]
 ii. What is the average waiting time for a customer? [3]
 iii. What is the utilization of the teller? [3]
 iv. What is the average time a customer spends in the system? [3]

QUESTION SEVEN

- a) Outline how simulation is used in Business system improvement. [10]
- b) Discuss the limitations of simulation. [4]
- c) Describe three types of simulation modeling methods. [6]

END OF QUESTION PAPER