## NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY



FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

MASTERS OF ENGINEERING -MANUFACTURING SYSTEMS AND OPERATIONS MANAGEMENT

2nd Semester Examination

COURSE : Modelling and Simulation
CODE : TIE 6210
DATE : May 2014
DURATION : 3 Hours

INSTRUCTIONS AND INFORMATION TO CANDIDATES

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1 Answer any Three (3) Questions from Section A.
2 Answer any Two (2) questions from Section B.
3 This paper contains eight (8) questions
4 The Four (4) printed pages
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Requirements
Supply Statistical Tables and graph paper

## SECTION A

## Question 1

a) Briefly describe the difference between a discrete simulation and continuous simulation.
b) Briefly discuss two advantages of simulation.
c) Briefly explain four processing features and their descriptors to be considered on software selection.
d) A baker is trying to determine how many dozen of rock buns to bake each day. The probability distribution of the number of rock buns customers is as shown in Table 1.1.
Table 1.1

| Number of <br> Customers/Day | 8 | 10 | 12 | 14 |
| :--- | :--- | :--- | :--- | :--- |
| Probability | 0.30 | 0.35 | 0.20 | 0.10 |

Customers order 1, 2, 3 or 4 dozen rock buns according to the following probability distribution shown in Table 1.2.
Table 1.2

| Number of Dozen Ordered <br> /Customer | 1 | 2 | 3 | 4 |
| :--- | :--- | :--- | :--- | :--- |
| Probability | 0.3 | 0.4 | 0.2 | 0.1 |

Table 1.3: Random Number Digit for Number of Number of Customers and Number of Orders

| Day | 1 | 2 | 3 | 4 | 5 |
| :--- | ---: | ---: | ---: | ---: | ---: |
| Random Digits for Customer | 12 | 40 | 37 | 97 | 40 |
| Random Digits for Dozen Ordered <br> /Customer | 72 | 47 | 55 | 44 | 72 |

Rock Buns sell for $\$ 5.40$ per dozen. They cost $\$ 3.80$ per dozen to make. All rock buns not sold at the end of the end of the day are sold at half-price to a local grocery store. Based on 5 days of simulation how many dozen ( to the nearest 10 dozen) buns should be baked each day?

## Question 2

a) Explain briefly the importance of random numbers generation in simulation.
b) Briefly describe uniformity test.
c) The sequence of numbers shown in Table 2.1 has been obtained from accidents on a highway. Use the Kolmogorov-Smirnov test with $\alpha=0.05$ to determine if the hypothesis that the numbers are uniformly distributed can be rejected.
Table 2.1; Records of 30 accidents involving an injury (the data represent the distance from a city.

| 98.8 | 23.7 | 90.1 | 17.2 | 97.4 |
| :--- | :--- | :--- | :--- | :--- |
| 32.4 | 62.6 | 87.8 | 69.8 | 99.7 |
| 88.3 | 27.3 | 40.7 | 36.3 | 36.8 |
| 91.7 | 45.2 | 67.3 | 7.0 | 23.3 |
| 20.6 | 6.0 | 73.1 | 21.6 | 45.3 |


| 76.6 | 87.6 | 73.2 | 27.3 | 87.2 |
| :--- | :--- | :--- | :--- | :--- |

## Question 3

a) Briefly discuss the Linear Congruential random number generation method.
b) Use the linear congruential method to generate a sequence of three two-digit random integers assuming $\mathrm{X}_{0}=117, \mathrm{a}=8, \mathrm{c}=47$, and $\mathrm{m}=100$.
c) Using the chi-square test with $\alpha=0.05$ test whether the data shown in Table 4.1 are uniformly distributed. Given $\mathrm{n}=10$ intervals.

Table 3.1: Random Numbers

| 0.43 | 0.09 | 0.52 | 0.98 | 0.78 | 0.44 | 0.21 | 0.12 | 0.64 | 0.76 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 0.38 | 0.67 | 0.97 | 0.46 | 0.07 | 0.18 | 0.49 | 0.47 | 0.22 | 0.47 |
| 0.69 | 0.99 | 0.77 | 0.76 | 0.65 | 0.14 | 0.25 | 0.37 | 0.99 | 0.20 |
| 0.74 | 0.03 | 0.71 | 0.28 | 0.65 | 0.50 | 0.54 | 0.13 | 0.87 | 0.50 |
| 0.97 | 0.17 | 0.32 | 0.91 | 0.28 | 0.39 | 0.56 | 0.73 | 0.93 | 0.24 |

## Question 4

a) Discuss briefly verification and two methods used in verification.
b) 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 the processing model for performing transactions.

## Question 5

a) Describe briefly four (4) error that can occur in random number generation.
b) Test whether the $3^{\text {rd }}, 8^{\text {th }}, 13^{\text {th }}$, and so on numbers in the sequence shown in Table 5.1 are autocorrelated (Using $\alpha=0.05$.)
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Table 5.1: Random Numbers

| 0.12 | 0.01 | 0.23 | 0.28 | 0.89 | 0.31 | 0.64 | 0.28 | 0.83 | 0.93 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 0.99 | 0.15 | 0.33 | 0.35 | 0.91 | 0.41 | 0.60 | 0.27 | 0.75 | 0.88 |
| 0.68 | 0.49 | 0.05 | 0.43 | 0.95 | 0.58 | 0.19 | 0.36 | 0.69 | 0.87 |

## SECTION B

## Question 6

a) Construct a Vensim System Dynamics (Stock and flow diagram) model for hiring software development staff where:
The Staff is initially set to $=30$
The Desired_Staff $=100$
The Hire_delay $=5$ months
The quit_rate $=5 \%(0.05)$ and release_rate $=15 \%(0.15)$
New_hires $=($ Desired_Staff - Staff $) /$ Hire_delay;
Staff_leaving = quit_rate * Staff+ release_rate * Staff;
b) Calculate the Staff level at equilibrium.
c) Calculate the new Desired_staff needed to achieve an equilibrium of $\operatorname{Staff}=100$
d) It was determined that a large part of the Staff leaving was due to poorly prepared new hires. An improved recruitment policy reduced the release rate to $5 \%$ but increased the hiring delay to 15 months. Calculate the new Desired_Staff needed to reach the needed staff level of 100 .

## Question 7

a) What are the two primary components of a system dynamics model and how do they function?
b) What are two other components of a system dynamics model and their function?
c) Define Reference mode.
d) Name, describe and draw the graph of four reference modes.

## Question 8

a) Construct a Vensim model where new employees are hired in as junior programmers. They remain junior programmers on average 36 months before becoming senior analysts. Initially the model has 20 junior programmers and 10 senior analysts. Employees are very satisfied so no one leaves accept Senior analysts that leave on average after 10 years. Only junior analysts are hired and the hiring delay is 10 months. Desired staff is 100 . The New hires recruited are the Desired Staff - (junior programmers + senior analysts). However, there is a hiring delay of 10 months to take into account. Draw the Vensim Stock and flow diagram.
b) Construct the equilibrium equations.

## END OF EXAM

