University of Chittagong

Department of Computer Science and Engineering

7th Semester B.Sc. (Engineering) Examination 2020

Course Title: Modeling and Simulation

Course No. CSE719, Full Marks: 52.5, Time: 4 Hours

Answer any three questions from each section

Section A

1. **a)** Illustrate the flow chart of overall structure of Java implementation of the simulation of a single-server queueing model. **3**

   b) Explain the Random Variate Generation of Triangular Distribution using Inverse Transformation Technique. **2.75**

   c) Perform the Kolmogorov-Smirnov test on the following random numbers: 0.41, 0.86, 0.17, 0.05, 0.93, and 0.34; Significance Level : 0.01. **3**

2. **a)** Explain the determination process of the model as valid or to refine the model depending on the best-case and worst-case error implied by the confidence interval with diagram. **2.75**

   b) The number of vehicles arriving at the northwest corner of an intersection in a five-minute period between 7:00 A.M. and 7:05 A.M. was monitored for five workdays over a twenty-week period, the sample size, n = 100.
   Following table shows the resulting data in twelve class intervals (0~11). The first entry in the following table indicates that there were 12 five-minute periods (f_1=12) during which zero vehicles arrived (x_1=0), and so on.
   For experimental input analysis, apply the Chi-Square goodness of fit test to verify the **exponential distribution** (PDF: $f(x)=\lambda e^{-\lambda x}$) for the given data. **6**
   Note: If the expected frequency is less than five for a class interval, then, that frequency will be combined with the neighbor class interval frequency to find out the reduced or ultimate number of class intervals, k. e = 2.718282. Number of parameter in exponential distribution, s = 1 (λ).

Table: Number of Arrivals in a Five-Minute Period

Arrivals per period	Frequency	Arrivals per period	Frequency
0	12	6	7
1	10	7	5
2	19	8	5
3	17	9	3
4	10	10	3
5	8	11	1

3 a) Define the following:
i) Simulation ii) Model iii) System State and iv) Environment **2**

b) Construct a table with ***Clock, Queue-State, Server-State, Checkout-Line, Future-Event-List, Busy-Time*** *and* ***Maximum-Queue-Length, Departed-Customers-Response-Time, Number-of-Customers-who-spend-Four-or-More-Minutes, and Total-Departures*** for the customers in the queueing system in the following simulation table. **6.75**

Customer Number	Arrival Time (clock)	Time Service Begins (clock)	Time Service Ends (clock)
1	0	0	2
2	2	2	3
3	6	6	9
4	7	9	11
5	9	11	12
6	15	15	19

4. a) Define ***Type I (α)*** and ***Type II (β)*** errors. How to control them? What is the relationship between them and why? **1.5**

b) Explain the Basic Genetic Algorithm to find a set of better solutions from the population models. **1.25**

c) A milling machine has three different bearings that fail in service. When a bearing fails, the mill stops, a *Repair-person* is called who installs a new bearing (costing $32 per bearing). The delay time for the *Repair-person* to arrive varies randomly. Downtime for the mill is estimated to cost $10 per minute. The direct on-site cost of the *Repair-person* is $30 per hour. The *Repair-person* takes 20 minutes to change **6**

one bearing, 30 minutes to change two bearings, and 40 minutes to change three bearings.
The mill-engineering-staff has proposed a new policy to replace all three bearings whenever one bearing fails. Management needs an evaluation of the proposal, using total cost as the measure of performance.
The two models (policies) were run by using Common Random Number (CRN) and for illustrative purposes, by using Independent Sampling (IS), each for R=10 replications per 10,000 bearing hours.
Overall error probability α=0.05.
i) Calculate mean, variance and standard error for each differences
ii) Find 95% confidence interval for each differences
iii) Choose the best model with explanation.

Table: Total Costs for Alternative Policies of Bearing Replacement

Replication R	Total Cost for Policies		
	Policy 2	Policy 1 IS	Policy 1 CRN
1	13,340	17,010	17,556
2	12,760	17,528	17,160
3	13,002	17,956	17,808
4	13,524	17,920	18,012
5	13,754	18,880	18,200
6	13,318	17,528	17,936
7	13,432	17,574	18,350
8	14,208	17,954	19,398
9	13,224	18,290	17,612
10	13,178	17,360	17,956

Section B

5. a) What are the four goals to compare more than two alternative models for simulation? **1.25**

b) Describe the Bonferroni approach for screening or selecting a subset from many alternate systems. **3.5**

c) The utilization of four independent replications (R_0=4) of two-hours duration of technical person Able is shown in the following table. **4**
Find out the additional number of replications needed to achieve the

desired precision within ± 0.04 with respect to the point estimator with probability 0.95. Given : $Z_{0.025} = 1.96$.

Table : Able's utilization for four independent replications

Run	Utilization
1	0.808
2	0.875
3	0.708
4	0.842

6. **a)** Write advantages & disadvantages of simulation. **3**

b) Illustrate the classification of models. **1.75**

c) A production process manufactures computer chips on the average at 2% nonconforming. Everyday a random sample size of 50 is taken from the process. If the sample contains more than two nonconforming chips, the process will be stopped.
i) Compute the probability that the process is stopped by the sampling scheme. **4**
ii) Consider the sampling process as Bernoulli trials. Determine the total number, mean, variance and standard deviation of nonconforming chips in a sample.

7. **a)** Differentiate between True Random Number and Pseudo Random Number. Illustrate the important considerations for Random Number Generator. **2.75**

b) Consider the 6 customers in the queueing system simulation in the following table. Calculate the followings.
i) Percentage of customer waited in the queue and server utilization
ii) Average time spent in system and in queue per customer **6**
iii) Average interarrival time and service time
iv) Average number of customers in system and in queue
v) Standard deviation and average waiting time of those who waited
vi) Variance and coefficient of variance of system time

Clock	**System State**		**Checkout Line**	**Future Event List**
	LQ (t)	LS (t)		

0	0	1	(C1,O)	(A,1,C2) (D,4,C1) (E,23)
1	1	1	(C1,O) (C2,1)	(A,2,C3) (D,4,C1) (E,23)
2	2	1	(C1,0) (C2,1) (C3,2)	(D,4,C1) (A,8,C4) (E,23)
4	1	1	(C2,1) (C3,2)	(D,6,C2) (A,8,C4) (E,23) ·
6	0	1	(C3,2)	(A,8,C4) (D,11,C3) (E,23)
8	1	1	(C3,2) (C4,8)	(D,11,C3) (A,11,C5) (E,23)
11	1	1	(C4,8) (C5,11)	(D,15,C4) (A,18,C6) (E,23)
15	0	1	(C5,11)	(D,16,C5) (A,18,C6) (E,23)
16	0	0	* * * *	(A,18,C6) (E,23)
18	0	1	(C6,18)	(D,23,C6) (E,23)
23	0	1	* * * *	* * * *

8 **a)** Differentiate between Discrete and Continuous System with necessary diagrams. **1**

b) Discuss the usage of Quantile-Quantile plot in input data analysis. **1.75**

c) Write the characteristics of Queueing System, Calling Population and Capacity. **1.5**

d) Consider a physician who schedules patients every 10 minutes. (PatientNo., ArrivalTime) : (1,0), (2,10), (3,20), (4,30) ... etc. He spends S_i minutes with the i-th patient, where S_i = 9 minutes with probability 0.9 and S_i = 12 minutes with probability 0.1. (PatientNo., ServiceTime) : (1,9), (2,12), (3,9), (4,9) ... etc. Find the following - **4.5**

i) Stability of the system
ii) Long run utilization of the physician
iii) Expected service time and variance of service time
iv) Expected interarrival time and variance of interarrival time
v) There is no waiting line at all : True/False

Appendix A: t distribution with v degree of freedom

v	$t_{0.005}$	$t_{0.01}$	$t_{0.025}$	$t_{0.05}$	$t_{0.10}$
1	63.66	31.82	12.71	6.31	3.08
2	9.92	6.92	4.30	2.92	1.89
3	5.84	4.54	3.18	2.35	1.64
4	4.60	3.75	2.78	2.13	1.53
5	4.03	3.36	2.57	2.02	1.48
6	3.71	3.14	2.45	1.94	1.44
7	3.50	3.00	2.36	1.90	1.42
8	3.36	2.90	2.31	1.86	1.40
9	3.25	2.82	2.26	1.83	1.38
10	3.17	2.76	2.23	1.81	1.37
11	3.11	2.72	2.20	1.80	1.36
12	3.06	2.68	2.18	1.78	1.36
13	3.01	2.65	2.16	1.77	1.35
14	2.98	2.62	2.14	1.76	1.34
15	2.95	2.60	2.13	1.75	1.34
16	2.92	2.58	2.12	1.75	1.34
17	2.90	2.57	2.11	1.74	1.33
18	2.88	2.55	2.10	1.73	1.33
19	2.86	2.54	2.09	1.73	1.33
20	2.84	2.53	2.09	1.72	1.32
21	2.83	2.52	2.08	1.72	1.32
22	2.82	2.51	2.07	1.72	1.32
23	2.81	2.50	2.07	1.71	1.32
24	2.80	2.49	2.06	1.71	1.32
25	2.79	2.48	2.06	1.71	1.32
26	2.78	2.48	2.06	1.71	1.32
27	2.77	2.47	2.05	1.70	1.31
28	2.76	2.47	2.05	1.70	1.31
29	2.76	2.46	2.04	1.70	1.31
30	2.75	2.46	2.04	1.70	1.31
40	2.70	2.42	2.02	1.68	1.30
60	2.66	2.39	2.00	1.67	1.30
119	2.62	2.36	1.98	1.66	1.29
120	2.62	2.36	1.98	1.66	1.29
∞	2.58	2.33	1.96	1.645	1.28

Appendix B:

Chi-square distribution with v degree of freedom

V	$X_{0.005}$	$X_{0.01}$	$X_{0.025}$	$X_{0.05}$	$X_{0.10}$
1	7.88	6.63	5.02	3.84	2.71
2	10.60	9.21	7.38	5.99	4.61
3	12.84	11.34	9.35	7.81	6.25
4	14.96	13.28	11.14	9.49	7.78
5	16.7	15.1	12.8	11.1	9.2
6	18.5	16.8	14.4	12.6	10.6
7	20.3	18.5	16.0	14.1	12.0
8	22.0	20.1	17.5	15.5	13.4
9	23.6	21.7	19.0	16.9	14.7
10	25.2	23.2	20.5	18.3	16.0
11	26.8	24.7	21.9	19.7	17.3
12	28.3	26.2	23.3	21.0	18.5
13	29.8	27.7	24.7	22.4	19.8
14	31.3	29.1	26.1	23.7	21.1
15	32.8	30.6	27.5	25.0	22.3
16	34.3	32.0	28.8	26.3	23.5
17	35.7	33.4	30.2	27.6	24.8
18	37.2	34.8	31.5	28.9	26.0
19	38.6	36.2	32.9	30.1	27.2
20	40.0	37.6	34.2	31.4	28.4
21	41.4	38.9	35.5	32.7	29.6
22	42.8	40.3	36.8	33.9	30.8
23	44.2	41.6	38.1	35.2	32.0
24	45.6	43.0	39.4	36.4	33.2
25	49.6	44.3	40.6	37.7	34.4
26	48.3	45.6	41.9	38.9	35.6
27	49.6	47.0	43.2	40.1	36.7
28	51.0	48.3	44.5	41.3	37.9
29	52.3	49.6	45.7	42.6	39.1
30	53.7	50.9	47.0	43.8	40.3
40	66.8	63.7	59.3	55.8	51.8
60	92.0	88.4	83.3	79.1	74.4
80	116.3	112.3	106.6	101.9	96.6
100	140.2	135.8	129.6	124.3	118.5

Appendix: C

Kolmogorov-Smirnov critical values

alpha N \	0.001	0.01	0.02	0.05	0.1	0.15	0.2
1	***	0.995	0.990	0.975	0.950	0.925	0.900
2	0.978	0.929	0.900	0.842	0.776	0.726	0.684
3	0.921	0.829	0.785	0.708	0.636	0.596	0.565
4	0.850	0.734	0.689	0.624	0.565	0.525	0.493
5	0.781	0.669	0.627	0.563	0.509	0.474	0.447
6	0.725	0.617	0.577	0.519	0.468	0.435	0.410
7	0.679	0.576	0.538	0.483	0.436	0.405	0.381
8	0.641	0.542	0.507	0.454	0.410	0.381	0.358
9	0.608	0.513	0.480	0.430	0.387	0.360	0.339
10	0.580	0.489	0.457	0.409	0.369	0.343	0.323
11	0.556	0.468	0.437	0.391	0.352	0.327	0.308
12	0.534	0.449	0.419	0.375	0.338	0.314	0.296
13	0.515	0.432	0.404	0.361	0.325	0.302	0.285
14	0.498	0.418	0.390	0.349	0.314	0.292	0.275
15	0.482	0.404	0.377	0.338	0.304	0.282	0.266
16	0.468	0.392	0.366	0.327	0.295	0.274	0.258
17	0.454	0.381	0.355	0.318	0.286	0.266	0.250
18	0.442	0.371	0.346	0.309	0.279	0.259	0.244
19	0.431	0.361	0.337	0.301	0.271	0.252	0.237
20	0.421	0.352	0.329	0.294	0.265	0.246	0.232
25	0.378	0.317	0.303	0.264	0.238	0.221	0.208
30	0.347	0.290	0.277	0.242	0.218	0.202	0.190
35	0.322	0.269	0.256	0.224	0.202	0.187	0.177
40	0.302	0.252	0.240	0.210	0.189	0.176	0.166
45	0.285	0.238	0.226	0.198	0.179	0.166	0.157
50	0.271	0.226	0.215	0.188	0.170	0.158	0.149