Name of the Program: B.Sc. in Computer Science and Engineering **08 September 2021**
Semester: Winter 2020-2021 **Time: 2:30 pm – 4:00 pm**

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
Department of Computer Science and Engineering (CSE)

Semester Final Examination **Winter Semester: 2020-2021**

Course Number: CSE 4549 **Full Marks: 75**
Course Title: Simulation and Modeling **Time: 1.5 Hours**

There are **4 (four)** questions. Answer all of them. Figures in the right margin indicate marks. The examination is **Online** and **Closed Book**. **CO** and **PO** of each question are written in the brackets underneath the marks.

Write your **Student ID** and **Name** on the top of the **first page** and your **student ID** and **page number** on the top of every page of the answer script.

Submit the pdf file of the scanned answer script with the filename **Full_Student_ID<space>Course_Code.pdf.**

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1. The cafeteria at IUT is trying to improve its service during the lunch rush hour from 1:25 to 2:25 PM. Students arrive together in groups of size 1, 2, 3, and 4, with respective probabilities 0.5, 0.3, 0.1, and 0.1. Interarrival times between groups are exponentially distributed with mean 15 seconds. Initially, the system is empty and idle, and is run for the 60-minute period. Each arriving student, whether alone or part of a group, takes one of three routes in the cafeteria:

   - Collection of Token, then rice, and then hot-curry
   - Collection of Token, then bread (‘rutee’), and then hot-curry
   - Collection of Token, then bread (‘rutee’), and then sweet-curry

   The probabilities of these routes are respectively 0.8, 0.1 and 0.1. At the token counter, there are two or more service men, each having his own queue, and there is no jockeying, students arriving to the counter simply choose the shortest queue. All queues in the model are FIFO. The rice counter is self-service. Assume that nobody ever has to queue there. The curry (both sweet and hot) and bread counters have their individual queues, and at least one service man provides the service.

   Identification of the students, at the counter, requires a time uniformly distributed between 30 to 50 seconds. A student needs to collect token for the bread and curry counters, does not need a token for the rice counter. For each token, a student requires an additional time uniformly distributed between 10-20 seconds. The service time at the bread counter is uniformly distributed between 30-50 seconds, whereas the service time at either of the curry counters is uniformly distributed between 50-100 seconds.

   For example, a route 1 student goes first to the token counter, joins the queue there, if necessary, identify himself and then collect the necessary token (only one token for the hot-curry), then goes to rice counter to take rice, and finally, goes to the hot-curry counter, joins the queue if necessary, and then takes the curry.

   The system is investigated to study the maximum and average delay at the queues, the maximum and average number of students in the queues, the maximum and total delays for each type of students, and overall average delay for all students.

   Currently, there are five service men in the cafeteria, two at the token counter, and one at each of the bread, hot- and sweet-curry counters, which can be assumed as the base case. The system is studied for both six and seven service men.

   a) What are the state variables and output variables for the simulation model? 3 (CO2, PO2)

b) Identify the set of events for the simulation model and mention the relation of each of the events with the state variable(s). 4 (CO2, PO2)

c) Write down the state equations for the simulation model. 5 (CO2, PO2)

d) Draw separate flow charts of the event routines (i.e., the event handler functions) for each of the events of the system. 12 (CO2, PO3)

e) Draw the flow chart of the function that updates the necessary statistical variables according to the output equations of the simulation model. 6 (CO2, PO3)

2. The highway between Gazipur and Mymensingh has a high probability of accidents along its 100 kilometers. The accident research institute from a university reveals that the occurrence of accidents along the 100 kilometers road is randomly distributed. However, news media assumes otherwise about the distribution. Assume you have been given the task to identify the true distribution. Say the Gazipur police department has published the accident record for the month of June, 2021. The records indicate the distance of the accident points from Gazipur representing a total of 30 accidents each of which involves an injury or death. The records are given below:

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

a) Draw the appropriate histogram from the data. From the histogram hypothesize a distribution that represents the data. 6 (CO2, PO2)

b) Use the Kolmogorov-Smirnov test to discover that the distances of the accident points have the hypothesized distribution. Finally, conclude whether the speculation of the media is correct or wrong. 9 (CO2, PO2)

3. Consider an (S, s) inventory system, in which the order quantity q is defined by 15 (CO4, PO2)

$$q = \begin{cases} S - I, & I \le s \\ 0, & I > s \end{cases}$$

where, I is the level of inventory at the inspection time, S is the maximum inventory level, and s is the order threshold.

The following results are obtained in four replications of four different (S, s) policies.

Rep.	(50,30)	(50,40)	(100,30)	(100,40)
1	\$233.71	\$226.21	\$257.73	\$261.90
2	\$226.36	\$232.12	\$252.58	\$257.89
3	\$225.78	\$221.02	\$266.48	\$258.16
4	\$241.06	\$243.95	\$270.61	\$270.51
$Y_{.i}$	\$231.73	\$230.83	\$261.85	\$262.12
S_i	\$7.19	\$9.86	\$8.19	\$5.89

where Y_i and S_i are the average and sample variance of the monthly cost of the four replications. Find out confidence intervals having an overall confidence level of 90% for the average monthly cost for each policy. Estimate the number of replications required to achieve a confidence interval that does not overlap for the pair (50, 30) and (50, 40).

4. For a time-shared computer model, where a single CPU is shared by a number of terminals in a round robin fashion with the time quantum q, suppose that the company is considering a change in the service quantum length q as well as an alternative priority policy in an effort to reduce the steady-state mean response time of a job. The values for q under consideration are 0.05, and 0.40 whereas the policies are original one and a priority one. Assume that there are n = 35 terminals and that the other parameters and initial conditions are the same. 15 (CO4, PO2)

For performing a 2^2 factorial experiment with these two factors ($q = 0.05$ *or* 0.40) and processing policy ($p = original\ or\ priority$) following responses for four design points were obtained in 10 replications, where R_i is the response of the i-th design points, $i = 1, 2, \dots, 4$.

Replication	R_1	R_2	R_3	R_4
1	14.79	4.32	11.61	4.37
2	14.12	4.47	8.31	4.99
3	12.54	9.50	9.46	5.22
4	14.73	5.37	12.75	4.64
5	10.56	5.10	9.04	4.82
6	11.45	6.37	9.95	4.05
7	11.16	6.38	9.64	4.55
8	10.07	6.36	9.52	5.07
9	12.72	6.27	11.18	7.10
10	12.04	7.59	8.00	4.58

The design points are given below:

Design points	q	p
1	−	−
2	+	−
3	−	+
4	+	+

Find the main and interaction effects for the factors and their 90% confidence intervals.

Appendix A

Modified critical values $c_{1-\alpha}$, $c'_{1-\alpha}$, and $c''_{1-\alpha}$ for adjusted K-S test statistics

		$1-\alpha$				
Case	**Adjusted test statistic**	**0.850**	**0.900**	**0.950**	**0.975**	**0.990**
All parameters known	$\left(\sqrt{n} + 0.12 + \frac{0.11}{\sqrt{n}}\right)D_n$	1.138	1.224	1.358	1.480	1.628
$N(\overline{X}(n), S^2(n))$	$\left(\sqrt{n} - 0.01 + \frac{0.85}{\sqrt{n}}\right)D_n$	0.775	0.819	0.895	0.955	1.035
$\text{expo}(\overline{X}(n))$	$\left(D_n - \frac{0.2}{n}\right)\left(\sqrt{n} + 0.26 + \frac{0.5}{\sqrt{n}}\right)$	0.926	0.990	1.094	1.190	1.308

Critical points $t_{\nu,\gamma}$ for the t distribution with ν df, and z_γ for the standard normal distribution

$\gamma = P(T_\nu \leq t_{\nu,\gamma})$, where T_ν is a random variable having the t distribution with ν df; the last row, where $\nu = \infty$, gives the normal critical points satisfying $\gamma = P(Z \leq z_\gamma)$, where Z is a standard normal random variable

	γ															
ν	**0.6000**	**0.7000**	**0.8000**	**0.9000**	**0.9333**	**0.9500**	**0.9600**	**0.9667**	**0.9750**	**0.9800**	**0.9833**	**0.9875**	**0.9900**	**0.9917**	**0.9938**	**0.9950**
1	0.325	0.727	1.376	3.078	4.702	6.314	7.916	9.524	12.706	15.895	19.043	25.452	31.821	38.342	51.334	63.657
2	0.289	0.617	1.061	1.886	2.456	2.920	3.320	3.679	4.303	4.849	5.334	6.205	6.965	7.665	8.897	9.925
3	0.277	0.584	0.978	1.638	2.045	2.353	2.605	2.823	3.182	3.482	3.738	4.177	4.541	4.864	5.408	5.841
4	0.271	0.569	0.941	1.533	1.879	2.132	2.333	2.502	2.776	2.999	3.184	3.495	3.747	3.966	4.325	4.604
5	0.267	0.559	0.920	1.476	1.790	2.015	2.191	2.337	2.571	2.757	2.910	3.163	3.365	3.538	3.818	4.032
6	0.265	0.553	0.906	1.440	1.735	1.943	2.104	2.237	2.447	2.612	2.748	2.969	3.143	3.291	3.528	3.707
7	0.263	0.549	0.896	1.415	1.698	1.895	2.046	2.170	2.365	2.517	2.640	2.841	2.998	3.130	3.341	3.499
8	0.262	0.546	0.889	1.397	1.670	1.860	2.004	2.122	2.306	2.449	2.565	2.752	2.896	3.018	3.211	3.355
9	0.261	0.543	0.883	1.383	1.650	1.833	1.973	2.086	2.262	2.398	2.508	2.685	2.821	2.936	3.116	3.250
10	0.260	0.542	0.879	1.372	1.634	1.812	1.948	2.058	2.228	2.359	2.465	2.634	2.764	2.872	3.043	3.169
11	0.260	0.540	0.876	1.363	1.621	1.796	1.928	2.036	2.201	2.328	2.430	2.593	2.718	2.822	2.985	3.106
12	0.259	0.539	0.873	1.356	1.610	1.782	1.912	2.017	2.179	2.303	2.402	2.560	2.681	2.782	2.939	3.055
13	0.259	0.538	0.870	1.350	1.601	1.771	1.899	2.002	2.160	2.282	2.379	2.533	2.650	2.748	2.900	3.012
14	0.258	0.537	0.868	1.345	1.593	1.761	1.887	1.989	2.145	2.264	2.359	2.510	2.624	2.720	2.868	2.977
15	0.258	0.536	0.866	1.341	1.587	1.753	1.878	1.978	2.131	2.249	2.342	2.490	2.602	2.696	2.841	2.947
16	0.258	0.535	0.865	1.337	1.581	1.746	1.869	1.968	2.120	2.235	2.327	2.473	2.583	2.675	2.817	2.921
17	0.257	0.534	0.863	1.333	1.576	1.740	1.862	1.960	2.110	2.224	2.315	2.458	2.567	2.657	2.796	2.898
18	0.257	0.534	0.862	1.330	1.572	1.734	1.855	1.953	2.101	2.214	2.303	2.445	2.552	2.641	2.778	2.878
19	0.257	0.533	0.861	1.328	1.568	1.729	1.850	1.946	2.093	2.205	2.293	2.433	2.539	2.627	2.762	2.861
20	0.257	0.533	0.860	1.325	1.564	1.725	1.844	1.940	2.086	2.197	2.285	2.423	2.528	2.614	2.748	2.845
21	0.257	0.532	0.859	1.323	1.561	1.721	1.840	1.935	2.080	2.189	2.277	2.414	2.518	2.603	2.735	2.831
22	0.256	0.532	0.858	1.321	1.558	1.717	1.835	1.930	2.074	2.183	2.269	2.405	2.508	2.593	2.724	2.819
23	0.256	0.532	0.858	1.319	1.556	1.714	1.832	1.926	2.069	2.177	2.263	2.398	2.500	2.584	2.713	2.807
24	0.256	0.531	0.857	1.318	1.553	1.711	1.828	1.922	2.064	2.172	2.257	2.391	2.492	2.575	2.704	2.797
25	0.256	0.531	0.856	1.316	1.551	1.708	1.825	1.918	2.060	2.167	2.251	2.385	2.485	2.568	2.695	2.787
26	0.256	0.531	0.856	1.315	1.549	1.706	1.822	1.915	2.056	2.162	2.246	2.379	2.479	2.561	2.687	2.779
27	0.256	0.531	0.855	1.314	1.547	1.703	1.819	1.912	2.052	2.158	2.242	2.373	2.473	2.554	2.680	2.771
28	0.256	0.530	0.855	1.313	1.546	1.701	1.817	1.909	2.048	2.154	2.237	2.368	2.467	2.548	2.673	2.763
29	0.256	0.530	0.854	1.311	1.544	1.699	1.814	1.906	2.045	2.150	2.233	2.364	2.462	2.543	2.667	2.756
30	0.256	0.530	0.854	1.310	1.543	1.697	1.812	1.904	2.042	2.147	2.230	2.360	2.457	2.537	2.661	2.750
40	0.255	0.529	0.851	1.303	1.532	1.684	1.796	1.886	2.021	2.123	2.203	2.329	2.423	2.501	2.619	2.704
50	0.255	0.528	0.849	1.299	1.526	1.676	1.787	1.875	2.009	2.109	2.188	2.311	2.403	2.479	2.594	2.678
75	0.254	0.527	0.846	1.293	1.517	1.665	1.775	1.861	1.992	2.090	2.167	2.287	2.377	2.450	2.562	2.643
100	0.254	0.526	0.845	1.290	1.513	1.660	1.769	1.855	1.984	2.081	2.157	2.276	2.364	2.436	2.547	2.626
∞	0.253	0.524	0.842	1.282	1.501	1.645	1.751	1.834	1.960	2.054	2.127	2.241	2.326	2.395	2.501	2.576

Exponential $f(x) = \lambda e^{-\lambda x}$

$$F(x) = 1 - e^{-\lambda x}$$

Normal $f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$

Individual Emperical

$$F(x_i) = \frac{i-1}{n-1} + \frac{x - X_i}{X_{i+1} - X_i} \times \frac{1}{n-1}$$

where, $i = \lceil u(n-1) \rceil$

Grouped Emperical

$$F(x) = F(a_{i-1}) + \frac{x - a_{i-1}}{a_i - a_{i-1}} \left[F(a_i) - F(a_{i-1})\right]$$

Co-variance: $C_j = \sum_{i=1}^{n-j} \frac{(X_i - \bar{X}_0)(X_{i+j} - \bar{X})}{n-j}$

Co-efficient of variation: $\hat{cv} = \frac{S_x}{\bar{x}}$

Lexis Ratio: $\hat{\tau} = \frac{S_x^2}{\bar{x}}$

Skewness: $\hat{v} = \frac{n^2}{(n-1)(n-2)} \times \frac{\frac{\sum_{i=1}^{n}(X_i - \bar{x})^3}{n}}{S^3}$

Chi-Square Test: $\chi^2 = \sum_{j=1}^{k} \frac{(N_j - nP_j)^2}{nP_j}$

Pair T-distribution:

$$\bar{X}_1(n_1) - \bar{X}_2(n_2) \pm t_{\hat{f}, 1-\alpha/2} \sqrt{\frac{S_1^2(n_1)}{n_1} + \frac{S_2^2(n_2)}{n_2}}$$

$$\hat{f} = \frac{\frac{S_1^2(n_1)}{n_1} + \frac{S_2^2(n_2)}{n_2}}{\frac{\left(\frac{S_1^2(n_1)}{n_1}\right)^2}{n_1 - 1} + \frac{\left(\frac{S_2^2(n_2)}{n_2}\right)^2}{n_2 - 1}}$$