ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

Department of Computer Science and Engineering (CSE)

MID SEMESTER EXAMINATION **WINTER SEMESTER, 2017-2018**

DURATION: 1 Hour 30 Minutes **FULL MARKS: 75**

CSE 4549: Simulation and Modeling

Programmable calculators are not allowed. Do not write anything on the question paper.

There are **4 (four)** questions. Answer any **3 (three)** of them.

Figures in the right margin indicate marks.

---

1. Consider a university cafeteria where no waiting staff service or table service is available. At present there exits two food-serving counters named *Main Counter (*serves main meal*)* and *Dessert Counter (*serves dessert item*)*. Students enjoy their meal service from *Main Counter*, and/or *Dessert Counter* by placing their individual service request at respective counters one by one. If a student arrives and finds the *Main Counter* idle, he/she is served immediately with his requested service, else he/she waits in a *FIFO* Queue. The students have the exponential inter arrival times with mean 2.1 minutes and the service time at *Main Counter* is also exponentially distributed with mean service time 2.0 minutes.

   At the completion of service by the *Main Counter*, a student either departs with p probability or requests next service to *Dessert Counter* with $(1-p)$ probability. The *Dessert Counter* requires exponential service time with mean 2.3 minutes. When the *Dessert Counter* remains busy at the time of service request, arriving students again wait in a FIFO queue associated with it. Upon service completion from *Dessert Counter,* students then return for additional service at the *Main Counter* again. For both counters, as any (served) student departs, if the queue is empty then the counter becomes idle, else a student from top of the queue is served immediately.

   Initially the system is empty and idle, and the simulation is to run for exactly 8 hours. The purpose of the simulation is to improve the system in terms of followings: average delay in each queue, the time average number in each queue, and the utilization of the each counter.

   a) What are the state variables and output variables for this simulation model? 4
   b) Identify the set of events for this simulation model. 5
   c) Write down the state equations for this simulation model. 7
   d) Write down the state space for this simulation model. 4
   e) Write down the output equations for this simulation model. 5

2. For the scenario given in Question 1 answer the followings:
   a) Draw a sample path of the system for a few initial minutes showing the change of the state variable(s) over time. 13
   b) Draw the separate flow charts of the events routines (i.e. the event handler functions) for any two of the events of the system. 12

3. a) Describe the characteristic properties of *Discrete Event Systems (DES).* 5
   b) List the steps of *Simulation Development Life Cycle.* 6
   c) Describe what you think would be the most effective way to study each of the following systems in terms of given possibilities below and discuss why. 6
      - Possible study approaches:
         i. Experiment with the physical model of the system
         ii. Experiment with the mathematical model of the system through simulation

- Given systems:
  i. Earth's thermodynamic in a particular geographic area
  ii. Small section of an existing inventory system
  iii. Traffic system in a metropolitan area
  iv. Water supply system in a commercial building
  v. Digital communication system in a battlefield

d) For each of the systems in Question 3.c, suppose that it has been decided to make a study via a simulation model. Discuss whether the simulation should be deterministic or stochastic, time-varying or time-invariant, and continuous state or discrete state. Justify your answers considering appropriate assumptions. 8

4. Consider a single server queuing system in which customers arrive according to Poisson process with rate λ1. Upon arriving, they either enter into service if the server is free or they join the queue. However, it is assumed that, each customer will only wait a random amount of time, having distribution *F*, in queue before leaving the system. Service time of a customer is exponential with rate λ2.

Suppose that each time the server completes a service, the next customer to be served is the one who has the earliest queue departure time. That is, if two customers are waiting and one would depart the queue if his/her service has not yet begun by time ***t1*** and the other if his/her service had not yet begun by time ***t2***, then the former would enter service if ***t1*** < ***t2***, and the later otherwise.

Assume that the following random variates are available:

- Inter-arrival Times (in second) are:
  Y_1= 0.4, Y_2= 0.3, Y_3= 0.4, Y_4= 1.7, Y_5= 1.7, Y_6= 0.5, and Y_7= 0.9
- Waiting Times (in second) are:
  X_1= 0.3, X_2= 0.8, X_3= 1.5, X_4= 0.6, X_5= 1.3, X_6= 0.2, and X_7= 1.1
- Service Times (in second) are:
  Z_1= 1.6, Z_2= 0.5, Z_3= 1.0, Z_4= 0.9, Z_5= 0.8, Z_6= 0.7, and Z_7= 1.1

2.1
1.5
0.9

a) Draw the sample path of the system for the above data 10

b) Mention the state(s) of the system at every event occurrence time. 5

c) Find the number of customers those left the queue 5

d) Find the average waiting time of the customer in the queue. 5