Boğaziçi University	**IE 306.02**	KORUGAN
Department of	System Simulation	Due Date:
Industrial Engineering	**Homework 1**	April 6^{th} 2025 at 23:59

Consider a system where individuals that get sick from a certain disease go to the hospital following an exponential rate of $\lambda = 1[\frac{patient}{h}]$. A sick person that arrives at the hospital must first be evaluated by a triage nurse who decides whether a patient should be treated in the hospital or should go home. The hospital has a total of S triage nurses that work in parallel. A nurse either finds the patient in stable condition (s), gives a treatment regime and sends the patient home for home care with probability p_1 or finds the patient in critical condition (c) and decides to admit him/her to the hospital with p_2 where $p_1 + p_2 = 1$. There are a total of K beds in the hospital. If a sick person is admitted by the nurse but there are no available beds then he/she is sent back home for home care as well.

- The evaluation time of an arriving patient by a triage nurse is distributed exponentially with rate μ_t. All nurses work independently at the same rate.
- The healing time of a patient in stable condition is distributed independently and exponentially with rate $\mu_s = 0.16[\frac{patient}{h}]$ in home care.
- The healing time of a critical patient that was admitted and was assigned an available bed is distributed independently and exponentially with rate μ_{cb}.
- The healing time of a critical patient that was sent home due to bed unavailability is distributed independently and exponentially with rate μ_{ch}. The average healing times of these patients are α times longer than those who could be treated at the hospital. Here α is uniformly distributed as $U[1.25, 1.75]$.

Part 1.1

- Build the conceptual model.
- Determine entities, their attributes, types of events, activities, delays, system states of interest. Show the random variables that are used for activities and delays.
- Generate a flowchart and pseudocode for your discrete event simulation model.
- Model this queueing network. Give the stationary analysis. Calculate average utilizations of nurses, average queue length of triage, rejection probability of critical patients, average number of occupied beds in hospital. average number of patients treated at home.

Part 1.2

In this part, you will code the main activity and process functions of an algorithm you will create in Part 2. The algorithm should have the main activities:

Generate_Interarrival(): To return interarrival times of sick people arriving at the hospital.

Generate_Nurse_Service_Time(): To return service times for people being served at one of the triage nurses.

Generate_Hospital_Healing_Time(): To return healing times for people being treated in the hospital bed.

Generate_Home_Healing_Time(): To return healing times for people that take self care at home. The function takes the input "s" for people that were found to be in stable condition and sent back home by the triage nurse and the input "c" for people that were found to be in critical condition but could not find a bed.

and these processes:

Arrival(): To execute the arrival process of a patient to the hospital.

Departure_Triage(): To execute the departure process of a customer from a triage nurse.

Treated_at_Hospital(): To execute the discharge process of a customer from a bed.

Advance_Time(): To advance the time to the next imminent event in the future event list.

Execute_Event(): Iterates through the future event list and executes the next imminent process.

For each function, you may use the built-in functions of python to create random exponential variables.

Part 2.1

First perform a hand simulation. Start the system empty. Generate event times using the codes you have generated earlier. Prepare a simulation table where you report the simulation time, future event list, and necessary model outputs in a table until the first 5 patients are healed. Write a brief explanation of your constructed table and comment on your results.

Part 2.2

Write an algorithm with the help of the functions you coded in part 1.2 that runs an event based discrete event simulation (Do not use SimPy). Report the simulation time, total number of sick people, number in triage queue, number of occupied triage nurses, number of occupied beds other necessary model outputs in a table for the first 20 events.

Using your event based simulation calculate the following model responses:

- long run marginal probabilities of being empty for triage or for the beds and the joint probability of both being empty.
- proportion of critical patients that are rejected due to bed unavailability.
- average utilization of each triage nurse

- average number of occupied beds in the hospital,
- proportion of patients that are treated at home,
- average time a sick person gets better.

Run all your simulations with the following three starting conditions:

- with an empty system,
- with half of the nurses and half of the beds full (if not divisible by 2 round down).
- with all nurses and beds full.

For each condition first run each simulation for 20, 200 and 1000 healed patients using the same random number seed. Then run the simulation for 20 replications and 200 healed patients to generate confidence intervals.

Input Parameters and the RN Seed

The input parameters that are not defined in the text are given in the input parameters table posted on the course website. Make sure you are using the parameter set assigned to your group.

Each group must use the grup specific random number seed calculated as the sum of group members' student ID numbers. For all simulation runs, including the hand simulation you need to use this random number seed.

Reporting and Submission of the Assignment

Parts 1.1 and 2.1 should be submitted in the pdf file. Make sure you explain all steps of your modeling process, all variables and parameters you use and your logic clearly. Include all your solutions, flowcharts, comments, tables etc. everything in pdf format.

For Part 1.2 and 2.2, you should submit your codes as a Jupyter notebook. Explain how your code works at each step and use proper documentation for each function. For the final simulation model you are expected to explain how you generate model outputs and responses of interest in the notebook.

You are also required to compare and discuss the results of your simulations of Part 2.2 thoroughly in the pdf report with the knowledge you have gathered in the course so far. If you observe differences in the results explain why you think these differences should or should not exist. If you see no differences comment on them as well. Are these expected results? Why do you think the results are (or are not) expected? Elaborate.

Submit one zipped file that contains both the pdf and the Jupyter notebook file by the due date. The file should not be larger than 2 Mb, it must be submitted through the Moodle website (e-mails and other means will be disregarded) and it should be named as: IE306- Asn-1-Group-Number-Lastname1-Lastname2.zip with names in alphabetical order. Only one member per group should submit the homework.