BZAN 546: Homework #4

Due Wednesday, May 10 @ 11:59am

1. An Operations Analyst for Cold Marble Ice Cream Shops Inc. needs help determining the appropriate number of clerks that are needed in his store. He is convinced a simulation model can help with this task. Data was collected over several days on the arrival process and it was found that customers arrive in the store in group sizes ranging from one to four people, with each size being equally likely. The number of groups per hour was also studied. It turned out to be described by a Poisson arrival process with an average of 24 groups per hour.

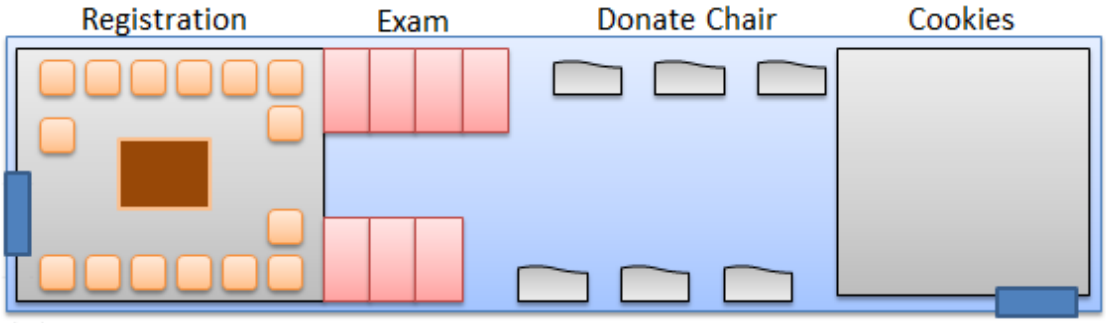
   It was further determined that customers who come to this store are only moderately patient. They will usually wait for about 7 minutes but not typically any longer. After 7 minutes the customers will renege the queue. Once a group gets their turn with a clerk, the same clerk will take the group through the entire process. This process includes ordering, picking & mixing the ice cream and toppings, and finally paying. If there are multiple people in a group, the one clerk will make all the ice creams orders and then one person in the group will pay the bill. Each clerk has their own work space so they are not getting into each other's way. The service times are provided in the table below:

Process	Service Time (minutes)	Description
Order	Triangular (0.25, 0.5, 0.4)	This time is for the entire group
Pick & Mix	Triangular (1.5, 3.0, 2.0)	This time is for each person in group
Pay	Triangular (0.5, 1.0, 0.75)	This time is for the entire group

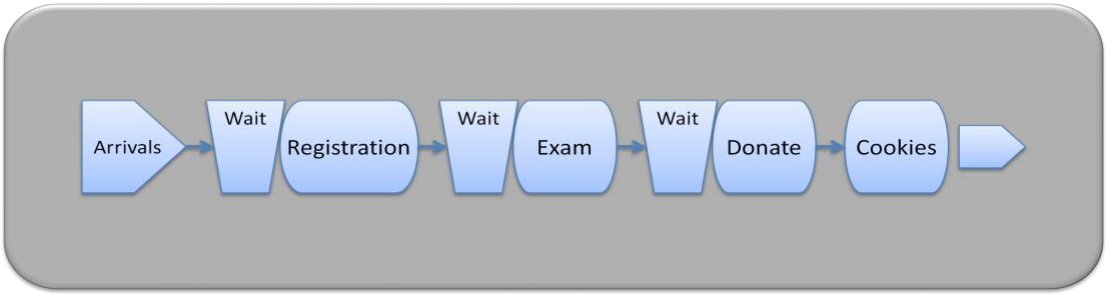
   Build a simulation model representing the system described above and help the operations analyst determine the appropriate number of clerks. Be sure to motivate your answer! Moreover, as you're formulating your recommendations, consider the following questions:

   a. Should you build a transient or a long-run, steady-state model for this scenario? As a result, should you run multiple replications or just one long run? Explain!
   b. What is the average customer waiting time and average clerk utilization?
   c. What is the average percentage of customers that end up reneging the queue due to long waiting times?

2. The International Green Cross Organization (IGCO) provides emergency services and resources. One of its main functions is to collect blood at its donation centers. Often faced with shortages in supply, the IGCO would like to make blood donation more appealing to potential donors. A research study found that one of the main reasons for potential donors not donating blood was that it required too much of their time. To better accommodate blood donors, IGCO wants to guarantee its donors that they will be able to complete the donation process in less than 90 minutes. The Blood Donation Center layout looks like the figure below.



The blood donation process is described in the flow chart below.



Each center has 1 registration desk, 7 exam cubicles, and 6 recliners for blood donation and process-related information is provided in the table below:

Process	**Capacity**	**Distribution**	**Minimum** (minutes)	**Maximum** (minutes)	**Most Likely** (minutes)
Registration	1	Triangular	0.5	1.5	1.0
Exam	7	Triangular	8	25	15
Donate Blood	6	Lognormal	(see information below)		
Cookie Area	No limit	Constant	-	-	15

It has further been determined that a patient's blood pressure would have an effect on the time it takes to give blood. For example, someone with low blood pressure would take longer than someone with high blood pressure. Assuming three blood pressure categories, low, normal, and high, the probabilities of occurrence for each category are 5%, 85%, and 10%, respectively. The times to donate blood come from the lognormal distribution with mean 15, 10, and 7 minutes, respectively (for low, normal, and high pressure) and standard deviation 3, 2, and 1 minute, respectively.

Moreover, because of work schedules, the rate at which donors arrive varies by the time of day (i.e., representing a "non-stationary Poisson arrival process"). Some of the volunteers at the center have done a statistical analysis of the inter-arrival times, as follows:

Time (minutes)	**Mean Interarrival** (minutes)	**Time** (minutes)	**Mean Interarrival** (minutes)
0	2	300	3
30	2.5	330	4
60	3	480	3
90	5	510	2
210	3	540	1.5
240	2	600	1.5

It has also been observed that not everyone who walks into IGCO Blood Donation Center will give blood. Some will leave because there are too many people waiting to get in. Some will leave after the exam process. The area between the entrance and the exam rooms is very small and consists of the arrival waiting line, the registration process, and the exam waiting line. If potential donors see more than 15 people waiting in that area when they arrive, they will leave without entering the system. This includes the queue before registration, registration, and the queue after registration. During the exam process, the nurse asks a series of questions regarding the medications the potential donors are taking. Typically, about 5% of the potential donors are taking medication that will preclude them from donating blood. The rejected donor candidates will skip the donate blood process but will still spend time in the refreshment area, just not as much time (lognormal distribution with a mean of 3 minutes and a standard deviation of 2 minutes). Finally, the Exam process and the Donate Blood process require technicians in order to process the donors. The technician is a resource with a limited capacity. One technician per donor is required during both the Exam process and the Donate Blood process as well. Considering the information provided above,

a. Should you build a transient or a long-run, steady-state model for this scenario? As a result, should you run multiple replications or just one long run? Explain! (you may assume that the center works 10 hours a day or that the center stops admitting donors after 10 hours, but will continue work until the last donor in the system is processed.)
b. Build a simulation model to determine the number of technicians needed to complete the donation process in less than 90 minutes (including the time spent on sampling cookies) with a 95% level of confidence.
c. Given your answer in part (b), find the average time spent in the process, as a function of a donor's blood pressure.

d. What is the average percentage of potential donors that leave because of congestion in the registration area (i.e., when there are more than 15 waiting, as described above)
e. What is the average utilization of resources corresponding to your answer in part (b)?
f. Would you have any recommendations for further reducing average donor waiting time?