**Department of Industrial and Systems Engineering**

**Indian Institute of Technology, Kharagpur**

**Simulation Lab**

**Time-2:00 pm to 5:00 pm Date: 29/01/2021**

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**Demonstration problem**

1. This system represents the final operations of the production of two different sealed electronic units, shown in the figure. The arriving parts are cast metal cases that have already been machined to accept the electronic parts.

The first units, called Part A, are produced in an adjacent department, outside the bounds of this model, with interarrival times to our model being exponentially distributed with a mean of 5 (all times are in minutes). Upon arrival, they’re transferred (instantly) to the Part A Prep area, where the mating faces of the cases are machined to assure a good seal, and the part is then deburred and cleaned; the process time for the combined operation at the Part A Prep area follows a TRIA (1, 4, 8) distribution. The part is then transferred (instantly, again) to the sealer.

The second units, called Part B, are produced in a different building, also outside this model’s bounds, where they are held until a batch of four units is available; the batch is then sent to the final production area we are modeling. The time between the arrivals of successive batches of Part B to our model is exponentially distributed with a mean of 30 minutes. Upon arrival at the Part B Prep area, the batches is separated into four individual units, which are processed individually from here on, and the individual parts proceed (instantly) to the Part B Prep area. The processing at the Part B Prep area has the same three steps as at the Part A Prep area, except that the process time for the combined operation follows a TRIA (3, 5, 10) distribution. The part is then sent (instantly) to the sealer.

At the sealer operation, the electronic components are inserted, the case is assembled and sealed, and the sealed unit is tested. The total process time for these operations depends on the part type: TRIA (1, 3, 4) for Part A and WEIB (2.5, 5.3) for Part B (2.5 is the scale parameter β and 5.3 is the shape parameter α). Ninety-one percent of the parts pass the inspection and are transferred immediately to the shipping department; whether a part passes is independent of whether any other part pass. The remaining parts are transferred instantly to the rework area where they are disassembled, repaired cleaned, assembled, and re-tested. Eighty percent of the parts processed at the rework area are salvaged and transferred instantly to the shipping department as reworked parts, and the rest are transferred instantly to the scrap area. The time to rework a part follows an exponential distribution with mean of 45 minutes and is independent of part type and the ultimate disposition (salvaged or scraped).

We want to collect statistics in each area on resource utilization, number in queue, time in queue, and the cycle time (or total time in system) separated out by shipping parts, salvaged parts, or scraped parts. We will initially rum the simulation for four consecutive 8-hour shifts, or 1920 minutes.



**Practice Problems:**

1. Two different part types arrive at a facility for processing. Parts of Type 1 arrive with interarrival times following a lognormal distribution with a log mean of 11.5 hours and log standard deviation of 2.0 hours (note that these values are the mean and standard deviation of this lognormal random variable itself); the first arrival is at time 0. These arriving parts wait in a queue designated for only Part Type 1’s until a (human) operator is available to process them (there’s only one such human operator in the facility) and the processing times follow a triangular distribution with parameters 5, 6, and 8 hours. Parts of Type 2 arrive with interarrival times following an exponential distribution with mean of 15.1 hours; the first arrival is at time 0. These parts wait in a second queue (designated for Part Type 2’s only) until the same lonely (human) operator is available to process them; processing times follow a triangular distribution with parameters 3, 7, and 8 hours. After being processed by the human operator, all parts are sent for processing to an automatic machine not requiring a human operator, which has processing times distributed as triangular with parameters of 4, 6, and 8 hours for both part types; all parts share the same first-come, first-served queue for this automatic machine. Completed parts exit the system. Assume that the times for all part transfers are negligible. Run the simulation for 5000 hours to determine the average total time in system (sometimes called cycle time) for all parts (lumped together regardless of type), and the average number of items in the queue designated for the arriving parts.
2. An office that dispenses automotive license plates has divided its customers into categories to level the office workload. Customers arrive and enter one of three lines based on their residential location. Model this arrival activity as three independent arrival streams using an exponential interarrival distribution with mean 10 minutes for each stream, and an arrival at time 0 for each stream. Each customer type is assigned a single, separate clerk to process the application forms and accept payment, with a separate queue for each. The service time is UNIF (8, 10) minutes for all customer types. After completion of this step, all customers are sent to a single, second clerk who checks the forms and issues plates (this clerk serves all three customer types, who merges into a single first-come, first-served queue for this clerk). The service tie for this activity is UNIF (2.65, 3.33) minutes for all customer types. Develop a model of this system and run it for 5000 minutes; observe the average and maximum time in a system for all customer types combined.

A consultant has recommended that the office not differentiate between customers at the first stage and use a single line with three clerks who can process any customer type. Develop a model of this system, run it for 5000 minutes, and compare the results with those from the first system.

1. A bank Lobby has four Tellers – Alice, Mary, Jeff and Doris – with similar working characteristics. The customer arrival pattern varies over time. The average number of arrivals per hour is 10, 20, 40, 36, 27, 32, 18, and 4 for each of the 8 one – hour period from the opening of the bank lobby until the closing time. During each period, the arrival process is poison. In addition, customers can arrive in groups of more than one. For each arrival instance, there is a 75 percent probability that it is a single customer, a 20 percent probability that that the group size consists of two customers, and a 5 percent probability that three customers are in group. The number of banking transactions for each customer is sampled from the distributions that was obtained from historical data and are as given below:

*Probability distribution of number of transaction per customer*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***Number of Transactions*** | *1* | *2* | *3* | *4* | *5* | *6* |
| ***Probability (%)*** | *20* | *30* | *22* | *15* | *8* | *5* |

A single queue serves all four tellers. When a customer enters the lobby, she will join the queue if the total number of customers in the lobby – that is, the number of customers being served plus the number of customers waiting in the queue is less than 10. Otherwise, she will balk. The service time for the customer depends on the number of transactions to be processed for the customers. Processing time for each transaction has an ERLANG distribution with a mean 1.08 minutes and the number of stages equal to 2. Eight hours of the bank lobby operations will be simulated i.e. from 9 AM to 5 PM. develop a simulation model and Collect the relevant statistics on above system.