Q1) Two part types arrive to a three-workstation system. Part type 1 arrives according to exponential distribution with interarrival-time mean 5 (all times are in minutes); the first arrival time is at time 0. This part type is first processed at work station 1 and then workstation 2. Its processing time at work station 1 follows a triangular distribution with minimum 2, mode 2.5 and maximum 4. Its processing time at workstation 2 follows a triangular distribution with minimum 3, mode 4.5 and maximum 7. Part type 2 arrives according to exponential distribution with interarrival-time mean 7; the first arrival time is at time 0. This part is first processed at work station 1 and then work station 3. . Its processing time at work station 1 follows a triangular distribution with minimum 2, mode 2.5 and maximum 4. . Its processing time at work station 1 follows a triangular distribution with minimum 3, mode 6.8 and maximum 8. Run your simulation model for a single replication of 2,000 minutes and observe the average and maximum time in system for each [art type separately; put a text box in your model with your results.

Q2) The press department of an automobile manufacturing facility runs two main operations, each with its own press machine: front-plate press operation and rear-plate press operation. These operations can be performed in any order, but both have to be performed for each arriving plate. Plates (jobs) arrive randomly and their interarrival times are exponentially distributed with mean 5 minutes. The service time in the front-plate press operation is distributed iid UNIF (1, 5) minutes, and in the rear-plate press operation it is distributed iid UNIF (2, 6) minutes. A plate joins the queue of the press operation with the least number of plates waiting at that time (since there is no sequencing requirement), Arena Basics 103 and on completion joins the queue of the other press operation after which it departs from the system. Finally, the press department is a three-shift facility running 24 hours a day. Develop an Arena model of the press department, and simulate it for one year with one replication. Estimate the following statistics: Average time arriving plates spend in the press department, utilization of the press machine in each operation, average queue delay at each operation, average time in the press department of those arriving plates that join first the rear-plate press operation, and then proceed to the front-plate press operation

Q3) Generalized Model 5-4 (in the text book) to have two additional types of items (doodads and kontraptions), as well as widgets; initially, there are 60 widgets, 50 doodads and 70 kontraptions. The customers arrive in the same pattern as before, but now each customer will have a demand for doodads and kontraptions, as well as for widgets. Widget demands are as before, doodad demands are POIS(1,9) and kontraptions demand are POIS(2,3); assume that the a customer’s demand for an item is independent of his or her demands for the other two items. There is still one inventory evaluator, who still arrives at the beginning of each day, but now has to look at all three inventories and order according to separate (s, S) policies for each of the three inventories, you may “clone” this inventory evaluator for this triple duty, using two tandem instances of the separate flowchart module. For widgets (s, S) = (20, 40) as before for doodads, (s, S) = (15, 35); and for kontraptions (s, S) = (25, 45). Delivery lags for widgets are UNIF (0.5, 1.0) as before; for doodads, it is UNIF (0.4, 0.8) and for kontraptions, it is UNIF (0.8, 1.7); note that for kontraptions, it is possible for a delivery lag to extend beyond the time of the next inventory evaluation, but make the order decision based on only the inventory on hand, rather than based on the inventory on hand plus on order. Ordering costs (both setup and incremental), holding and shortage costs for doodads and kontraptions are the same for widgets. Run the simulation for the same length as model 5-4 (that is, it is ok to fudge the ending point to avoid useless inventory evaluation at time 120), and get the total daily cost, as well as separate holding and shortage costs for each type of items in inventory. Describe how you model this if you had hundreds or thousands of different kinds of items inventory instead of just three.

 Q4) Three types of customers arrive at a small airport: check baggage (30%, that is, for each arriving customer there is a 0.3 probability that this is a “check-baggage” customer), purchase ticket (15%), and carry-on (55%). The interarrival-time distribution for all customers combined is EXPO (1.3); all time in minutes and the first arrival is at time 0. The bag checkers go directly to the check-bag counter to check their bags- the time for which is distributed TRIA (2, 4, 5) - proceed to X-ray, and then go to the gate. The ticket buyers travel directly to the ticket counter to purchase their tickets-the time for which is distributed EXPO (7)-proceed to X-ray, and then go to the gate. The carry-ons travel directly to the X-ray, then to the gate counter to get boarding pass-the time for which is distributed TRIA (1, 1.6, 3). All three counters are staffed all time with one agent each. The X-ray time is EXPO (1). All times are EXPO (2), except for the carry-on time to the X-ray, which is EXPO (3). Run your model for a single replication of length 920 minutes and collect statistic on resource utilization, queues, and the system time from entrance to gate for all customers combined. For the output statistics requested, put a text box inside your Arena file. For “queues” and “system time” report both the average and maximum.

Q5) Part arrives every 10 minutes to a system having three workstations (A, B and C), where each workstation has a single machine; the first part arrives at time 0. There are four types, each with equal probability of arriving. The process plans for the four part types are given here. The entries for the process times are the parameters for a triangular distributions (in minutes).

|  |  |  |  |
| --- | --- | --- | --- |
| Part Type  | Workstation/Process Time | Workstation/Process Time | Workstation/Process Time |
|  | A (5.5, 9.5, 13.5) | C (8.5, 14.1, 19.7) |  |
|  | A (8.9,13.5,18.1) | B (9,15,21) | C (4.3,8.5,12.7) |
|  | A (8.4,12,15.6) | B (5.3,9.5,13.7) |  |
|  | B (9.3,12.6,16.0) | C (8.6, 11.4, 14.2) |  |

Assume that the transfer time between arrival and first station, between all stations, and between the last station and the system exist is 3 minutes. Use the sequence feature to direct the parts through the system and assign the processing times at each station. Use the Sets feature to collect the cycle times (total times in the system) for each of the part types separately. Animate your model (including the part transfers), run the simulation for single replication of length 10,000 minutes, and collect statistics on average part cycle time (report this in a text box in your Arena model file).

Q6) Change your model in Question 5 to include fork truck to transport the parts between stations. Assume that there are two fork trucks that each travel at 85 feet per minute. Loading or unloading a part by the fork truck requires 0.25 minute. The distance between stations is given (in feet) here; note that the distances are, in general, directional:

|  |  |  |
| --- | --- | --- |
|  |  | To |
|  |  | Arrive | WS A | WS B | WS C | Exit |
| From | Arrive | 0 | 100 | 100 | 200 | 300 |
| WS A | 100 | 0 | 150 | 100 | 225 |
| WS B | 100 | 150 | 0 | 100 | 200 |
| WS C | 250 | 100 | 100 | 0 | 100 |
| Exit | 350 | 250 | 225 | 100 | 0 |

Run you simulation for 100,000 minutes (you may want to turn off animation via Run>Run Control> Batch Run (no Animation) command after confirming that things working properly), and record the part cycle times. Assume that fork trucks remain at the station where they unloaded the last part if no other request is pending. If both fork trucks are available, assume that the closet one is selected.

Q7) Customers arrive, with interarrival times distributed as EXPO (5) - all times are in minutes- at small service center that has two servers. Each with a separate queue. The service times are EXPO (9.8) and EXPO (9.4) for server 1 and 2, respectively. Arriving customers join the shortest queue. Customers line switching occurs whenever the difference between the queue lengths is 3 minutes or more. At that time, the last customer in the longer queue moves to the end of the shorter queue. No additional movement, or line switching, in that direction occurs for at least the next 30 seconds. Develop a model and animation of this system and run it for 10,000 minutes. Observe statistics on the number of line switches, resource utilization, and queue lengths.