**MS3106 Simulation Final Exam**

2021-2022 Semester A

**Please read the exam guidelines and sign the honor pledge (10% of total points will be removed if not signed).**

1. This exam is closed-book and closed-notes (one A4 size cheat sheet is allowed).
2. You will work on a computer;use Excel and Arena v16.0 to solve the exam questions.
3. Final exam duration is 2 hours from 2 pm to 4 pm. You will be given 10 minutes to submit your solutions. Time constraint will be strictly enforced. Submission after 4:10 pm will be treated as late and**20 points will be deducted from your final exam score**. **The exam submission link will be disabled at 4:15 pm. Submission after that will not be accepted.** Hence, I encourage you to submit early. Note that you can submit multiple times through Canvas, and only the last submission counts.
4. Your answers should be reported in this word file; submit your model files (Excel or Area) together with this word file via Canvas.
5. If you cannot login Canvas, send your files through email: [zhankun.sun@cityu.edu.hk](mailto:zhankun.sun@cityu.edu.hk) **by the due time. Late submission will be dealt with in the same way as described in Item 3.**
6. No collaboration or communications are allowed. Failure to follow this rule will get 0 in this exam.

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| **CityU Honor Pledge:** I affirm that I will not give or receive any unauthorized help on this exam, and that all work will be my own. A direct result of any violation of the honor pledge is failing this course. |
| **Signature by tying in your full name:** |

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| Question 1. (40pts)  A battery manufacturer is considering developing a new electric-vehicle battery, called ATL battery. Based on a preliminary study, the manufacturer made the following estimates.  The fixed cost of developing the ATL battery follows a triangular distribution with minimum $110 million, most likely $120 million, and maximum $135 million; note that fixed cost incurs only once. The manufacturer will produce and sell ATL battery for 5 years.  a) The demand of the battery in year 1 follows a Normal distribution with mean 100,000 and standard deviation 5,000. In each year after year 1, the demand follows a normal distribution with mean equal to the actual demand in the previous year and standard deviation 5,000.  b) Selling price (per unit) in year (where ) is denoted by . The selling price in year 1 is , i.e., . In each year after year 1, i.e., , the selling price is , where is calculated by [actual demand - expected demand] / expected demand in the year , .  For example, if year 1’s actual demand is 90,000 and year 1’s expected demand is 100,000, then and year 2’s selling price is 1.04\*[$950+$500\*(-10%)]=$936.  c) Production quantity is equal to the expected demand in each year. If production quantity exceeds the actual demand, the exceeded batteries are sold at the actual selling price of that year multiplied by a deflation factor. The deflation factor is 0.8 with probability 0.35, 0.75 with probability 0.4, 0.7 with probability 0.25.  d) Variable production cost (per unit) in year 1 is $400 with probability 0.3, $420 with probability 0.45, and $440 with probability 0.25. In each year after year 1, variable production cost is equal to the actual variable production cost in the previous year times an inflation factor; and this inflation factor follows a Normal distribution with mean 1.05 and standard deviation 0.01.  Hint: EXCEL FUNCTIONS: NORM.INV(), STDEV(), AVERAGE(), VLOOKUP(), and others |
| (a)(20pts) Run the simulation for 500 replications, estimate the mean and standard deviation of the manufacturer’s net profit in developing and selling the ATL battery for five years.  (Save your model Q1a.xlsx and submit it on Canvas. Your results reported here might be different from your submitted Excel file, which is fine.) |
| Answer: |
| (10pts) Calculate the frequency of the manufacturer’s net profit and plot a bar chart, and estimate the probability that the net profit is greater than $150 million.  (Save your results in Q1a.xlsx) |
| Answer: |
| (b)(10pts) Suppose the production quantity is equal to θ times the expected demand in each year. What is the average net profit when θ is 0.9, 1.1, and 1.2, respectively? Note that all other parameters remain unchanged and run the simulation for 500 replications for each case.  (Save your model Q1b.xlsx and submit it on Canvas. Your results reported here might be different from your submitted Excel file, which is fine.) |
| Answer: |
| **Question 2 (60 pts)**  Two classes of jobs enter a computer repair clinic: scheduled jobs and unscheduled jobs. Scheduled jobs arrive in batches of two, once per hour; unscheduled jobs arrive randomly according to a Poisson distribution at rate one per hour (i.e., the interarrival times follow an exponential distribution with the same rate).  The repair clinic consists of two services: an inspection desk with two servers and a repair room with one server. All arriving jobs first need to go through the inspection process. Unscheduled jobs take priority over scheduled jobs at the inspection desk; they have equal priority at the repair room. However, not all jobs need repair: 5% of all scheduled jobs require repair and 40% of all unscheduled jobs require repair.  All service times follow exponential distributions: scheduled jobs take an average of 20 minutes to be inspected and 60 minutes to repair, unscheduled jobs take an average of 40 minutes to be inspected and 90 minutes to repair.  The repair clinic runs for 24 hours a day. For all the questions below, run the simulation for 30 replications, each replication with a length of 20 days. Use “minutes” as the base time unit. |
| (a)(20pts) Use Arena to build a simulation model. Report the average and half width of the waiting times at the repair room (keep two decimal places). (Save your model as Q2a.doe and submit it on Canvas.) |
| Answer: |
| (b)(10pts) Report the average and half width of the waiting times of unscheduled jobs at the inspection desk (keep two decimal places). (Save your model as Q2b.doe and submit it on Canvas.) |
| Answer: |
| (c)(10pts) In this part, make a copy of your Q2b.doe and save it as Q2c.doe. You will be asked to add features to this model.  Now, assume that after inspection, a job that needs repairment will abandon, i.e., leave the clinic without repair, if there are more than two jobs waiting for repair in the repair room. Update your Arena model, run it, and report the average and half width of the abandonment rate (keep two decimal places). (Save your model Q2c.doe and submit it on Canvas.) |
| Answer: |

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| (d)(10pts) In this part, make a copy of your Q2c.doe and save it as Q2d.doe. You will be asked to add features to this model.  Now, assume that the arrival rates of the unscheduled jobs have the following pattern:   |  |  | | --- | --- | | Time Period | Arrival Rate | | 0:00 – 6:00 | 0.2/hour | | 6:00 – 12:00 | 1.8/hour | | 12:00 – 18:00 | 1.5/hour | | 18:00 – 24:00 | 0.5/hour |   Update your Arena model, run it, and report the average and half width of the abandonment rate (keep two decimal places). (Save your model as Q2d.doe and submit it on Canvas.) |
| Answer: |
| (e)(10pts) In this part, make a copy of your Q2d.doe and save it as Q2e.doe. You will be asked to add features to this model.  Next, we model a phenomenon called “blocking” which is commonly seen in manufacturing and service systems. Assume that there is limited waiting room at the repair room (referred to as buffer size hereafter). Here is what will happen: if a job finishes inspection and needs repair, however, all the buffers at the repair room are occupied by other jobs, then the job whose inspection is just finished stays in the inspection desk and continues to occupy a resource at inspection. We call this phenomenon that a resource in the upstream is being blocked by a service in the downstream. This job leaves the inspection desk once there is available buffer at the repair room.  Hint: you can use a module from the Advanced Process panel called “Hold.” This module can temporarily store the entity and scan for certain condition. If the condition is satisfied, the entity held by the “Hold” module will be released.  Assume that the buffer size is one, i.e., there can be at most one job waiting to be repaired at the repair room. Update your Arena model, run it, and report the average and half width of the waiting times at the repair room (keep two decimal places). (Save your model as Q2e.doe and submit it on Canvas.) |
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