**MS3106 Final Exam**

2020-2021 Semester A

**Please read the following guidelines for the final exam, and sign the honor pledge.**

1. This exam is open-book and open-notes; try to finish all problems.
2. You will work on a computer **with camera;** use Excel and Arena v16 to solve the exam questions.
3. You are **required to join the Zoom meeting** during the final exam **with your camera open**. The zoom meeting is posted on Canvas. The meeting ID is 916 7261 3491 with password 8x102q.
4. Final exam duration is 2 hours from 9:30am to 11:30am. You will be given 10 minutes to submit your solutions. Time constraint will be strictly enforced. Submission after 11:40am will be treated as late and**20 points will be deducted from your final exam score**. **The exam submission link will be disabled at 11:50am. 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.
5. Your solutions should be reported in this word file; submit your model files (Excel or Area) together with this word file on Canvas.
6. If you cannot login Canvas, send your exam answers 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 4.**
7. No collaboration or communications are allowed. Failure to follow this rule will get 0 in this exam.
8. In case of emergency, contact me at +852 3442 8650.
9. The departmental hotline is +852 3442 8585.

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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. (50pts) model file: Q1.xlsx  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. A quality test is conducted after completion of development.  If quality test is failed (with 15% chance), ATL battery is abandoned and the manufacturer cannot gain any revenue. If passing quality test (with 85% chance), the manufacturer will produce and sell ATL battery for 5 years. See more details bellow.  a) Demand. 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 previous 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)(30pts) Run the simulation for 500 replications, estimate the mean, standard deviation, and 95% confidence interval of the manufacturer’s net profit in developing and selling the ATL battery for five years. |
| Answer: |
| (b)(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. |
| Answer: |
| (c)(10pts) Suppose the production quantity is equal to θ times the expected demand in each year. What is the average net profit if 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. |
| Answer: |
| **Question 2 (50 pts)**  At a local clinic in Hong Kong, patients arrive to the hospital according to an unknown distribution. Each incoming patient is an emergent patient with 30% chance, and a regular patient with 70% chance. Each patient must go through two phases of services: first the body check and then physician assessment. The hospital will give emergent patients a higher priority over regular patients for both the body check and physician assessment. The body check takes an Exponential (6) minutes and requires one nurse. There are two nurses performing the body check. Patients wait for the body check in a single line. After the body check, the patients will be waiting in a single queue for the physician assessment (each patient requires one physician). There are two physicians available. The physician assessment takes a Triangular (3, 4, 5) minutes. After physician assessment, there is 40% chance that a patient needs blood test. Blood tests take Exponential (2) minutes and one worker perform the tests. Finally, all patients are discharged after treatment in the clinic. |
| (a)(5pts) We have collected a dataset on the patient interarrival times, see **patientarrival.txt**. Use the input analyzer in Arena to find the distribution that best fits the data. Report the histogram and the distribution with the corresponding parameters. Use this distribution as the input in your simulation model for patient arrivals (note that the time unit is in minute).  Note: empirical distribution is excluded; also, when there are more than one distribution that fits the data well, choose the simpler one. For example, Gamma/Weibull distributions are more complex than Erlang distribution, which is more complex than exponential distribution. (Because they have more parameters.)  (25pts) Run the simulation for 1 replication with length 60 days (In this problem, we set 1 day=24 hours). Report both mean and 95% confidence interval of the cycle time (or total time) for each patient. (Save your model as Q2a.doe and submit it on Canvas.) |
| Answer: |
| (b)(10pts) Following the model in (a), now suppose that the emergent patients require a longer time for physician assessment, which is Triangular (4, 5, 6) minutes. The durations for the regular patients following Triangular (3, 4, 5) minutes. Under this modification, run the simulation for 1 replication with length 60 days. Report both mean and 95% confidence interval of the cycle time (or total time) for each patient. (Save your model as Q2b.doe and submit it on Canvas.) |
| Answer: |
| (c) Following the model in (a), now that due to the space constraint the total number of patients in the clinic cannot exceed 10 patients. If there is already 10 patients in the clinic, a new arriving patient will be rejected. Under this modification, run the simulation for 1 replication with length 60 days. (Save your model as Q2c.doe and submit it on Canvas.)  (7pts) Report both mean and 95% confidence interval of the cycle time (or total time) for each patient.  (3pts) What is the chance that an arrival patient gets rejected? Estimate it from the single replication you just ran with your simulation model. |
| Answer: |