**MS3106 Simulation Final Exam**

2020-2021 Semester B

**Please read the exam guidelines and sign the honor pledge (20% of your points will be removed if not signed).**

1. This exam is open-book and open-notes (limited to lecture notes and class videos).
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**.
4. 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 4:20 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.
5. Your answers 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. (40pts)  Teslia Motor is considering whether to introduce a new electric car model called the Teslia W. The profitability of the Teslia W will depend on the following factors:  a. Fixed cost of developing the Teslia W: Fixed cost is equally likely to be $2.4, $3.5 or $4.5 billion, i.e., the probability of each outcome is 1/3. The fixed cost incurs only once in year 1.  b. Sales: Assume that year 1 sales will be normally distributed with mean 140,000 and standard deviation 45,000. Sales are expected to increase each year for years 2, 3, 4, and the percentage increase during those years is a discrete random variable: 5% with probability 0.4, 8% with probability 0.3, and 10% with probability 0.3. Use Excel function ROUNDDOWN to round the yearly sales down to the nearest integer; e.g., =ROUNDDOWN(3.11, 0) will give you 3.  c. Price: Assume year 1 price is $12,000. The sales price of years 2, 3, and 4 will increase by 5% with probability 0.4 and 8% with probability 0.6 each year from the price of the previous year.  d. Variable cost per car: variable cost is equally likely to be $4000, $7000, $8000, or $9000 during year 1, i.e., the probability of each outcome is 1/4. The variable cost is expected to increase during each of the following 3 years. The percentage increase is a discrete random variable: 4% with probability 0.6 and 5% with probability 0.4.  Hints:   * EXCEL FUNCTIONS: NORM.INV(), STDEV(), AVERAGE(), VLOOKUP() * Q1.xlsx provides an exemplary template. Feel free to modify the template in Q1.xlsx. * The automatic calculation option is not enabled in Q1.xlsx. Press F9 to recalculate. |
| (a)(20pts) Simulate 500 trials and estimate the mean and standard deviation of the net profit for the first four years of sales and development for the Teslia W. |
| Answer:  (This question will be graded on your Excel submission. No need to put anything here.) |
| (b)(7pts) Since there are loyal customers for environment-friendly cars, Teslia enjoys a certain degree of monopoly. Compute the average and standard deviations of the net profits of Teslia W for the four years if it increases Year 1 prices to $13,000, $14,000, $15,000, $16,000, respectively. Suppose that all other problem parameters remain unchanged and simulate 500 trials for each case.  (3pts) For each of the four choices of Year 1 prices, make a plot of the mean and standard deviation of the net 4-year profits computed before. (Similar to the one below, which is from our class example). |
| Answer: (The average and standard deviations will be graded based on your Excel submission. Copy your plot here.) |
| (c)(7pts) Suppose that the standard deviation of year 1 sales changed to 50,000, 55,000, 60,000, 65000, Compute the corresponding average and standard deviation of the net profits for the four years. Suppose that all other problem parameters remain unchanged and simulate 500 trials for each case.  (3pts) Similar to part (b), for each of the choices of the standard deviations of year 1 sales, make a plot of the mean and standard deviation of the net 4-year profits computed before. |
| Answer: (The average and standard deviations will be graded based on your Excel submission. Copy your plot here.) |
| **Question 2 (60 pts)**  **Patient arrival process:** Patients arrive to the clinic according to a certain distribution. Follow the screenshot below to use the Create module to create patient arrivals. A single physician works in this clinic for an 8-hour shift per day.    Use your student ID as the number of maximum arrivals  **Limited clinic beds:** There are 10 treatment beds in the clinic. A new arriving patient who finds no available bed will be rejected and leave without being seen; otherwise, the patient enters the clinic and will be assigned a bed immediately. The patient will occupy a bed during his/her stay in this clinic. The bed will be emptied and cleaned (assume this can be done instantaneously) for the next patient once this patient finishes his/her treatment in the clinic.  **Patient flow process:** Upon entering the clinic,a patient will first see the physician for initial assessment. If the physician is busy, the patient will need to wait for his/her turn. The initial assessment time follows an exponential distribution with mean 15 minutes.  After initial assessment, the physician will decide whether the patient needs certain diagnostic tests. Statistical analysis of historical data shows that 34% of patients need tests. If a patient does not need test, s/he leave the clinic immediately. Otherwise, s/he goes to a test center for testing. The testing time is exponentially distributed with mean 90 minutes. Note that testing does not require any resource.  After testing, a patient will go back to the same physician for reassessment. The reassessment time follows an exponentially distribution with mean 12 minutes. After reassessment, the physician decides whether the patient needs another round of diagnostic tests, and again, 34% of the patients need tests. If a patient does not need test, s/he leave the clinic immediately; otherwise, s/he goes to the test center for testing and goes back to the physician for reassessment. This process can repeat itself, i.e., a patient may go through multiple rounds of testing and reassessment, until the patient leaves the clinic.  In your simulation model, define two types of entities, **new patient** and **old patient**.“New patient” refers to patients who have not seen the physician, and “old patient” refers to the patients who have seen the physician for initial assessment and come back to the physician for reassessment. |
| (a)(20pts) Use Arena to build a simulation model. Run the simulation for 20 replication with length 1 day (In this problem, we set 1 day=8 hours). Report the average and half width of the waiting times for both new and old patients. (Save your model as Q2a.doe and submit it on Canvas.) |
| Answer: |
| (b)(10pts) In this part, make a copy of your Q2a.doe and save it as Q2b.doe. You will be asked to add features to this model.  The physician decides to give priority to “old patients” who come back to this physician for reassessment over “new patients.” Modify your model and run the simulation for 20 replication with length 1 day (1 day=8 hours). Report the average and half width of the waiting times for both new and old patients. (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.  We want to learn the number of new patients seen per hour, i.e., how many new patients are seen by this physician during each hour of his/her 8-hour shift. Modify your model and run the simulation for 20 replication with length 1 day (1 day=8 hours). Report the average (and half width) of the number of new patients seen per hour during the 8-hour shift. (Save your model Q2c.doe and submit it on Canvas.)  Hint: Add a record module to your model and define 8 new Counters, namely, PPH 1, PPH 2, …, PPH 8. You will need to use the Set data module as well. |
| Answer: |

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| (d)(10pts) In this part, make a copy of your Q2b.doe and save it as Q2d.doe. You will be asked to add features to this model.  Now that the physician wants to prioritize patients with more rounds of tests, since their treatments are more likely to finish soon. For example, a patient who has done two rounds of tests has priority over patients who has done one round of test, which has priority over new patients (who have zero test done). Modify your model and run the simulation for 20 replication with length 1 day (1 day=8 hours). Report the average and half width of the waiting times for both new and old patients. (Save your model as Q2d.doe and submit it on Canvas.) |
| Answer: |

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| (e)(10pts) In this part, make a copy of your Q2b.doe and save it as Q2e.doe. You will be asked to add features to this model.  Suppose that once a patient’s treatment is complete, it takes the clinic some time to clean the bed so that it is available to serve the next patient. Assume that the cleaning time follows a uniform distribution between 10 to 20 minutes. Modify your model and run the simulation for 20 replication with length 1 day (1 day=8 hours). Report the average and half width of the waiting times for both new and old patients. (Save your model as Q2e.doe and submit it on Canvas.) |
| Answer: |