APMA 3100 – Probability • Sec 003 – McMillan • Coding Project 2

Report Due Date: 12/05/2025, 11:59pm, in Gradescope

[0.2% class extra credit + graded before final: if submitted by 11/25/2025, 11:59pm]

Monte Carlo simulation is a technique used to simulate the behavior of random processes (defined by a combination of randomness and deterministic procedure), and to solve problems that are analytically intractable (such as those involving nonlinear differential equation systems). Your last project implemented a very simple example of Monte Carlo simulation. This project implements a more complex example.

Scenario

Your group has been hired by a ticketing agency who employs customer service agents. The agency will use the information you provide to make staffing decisions. The customer service agents help customers purchase tickets over the phone. The agency provides you with the following information about the calling process.

- They first must dial and wait to be connected, which takes 7 seconds.
- Then the caller will either be connected immediately to an agent, with probability 0.40, or put on hold with probability 0.60.
- The amount of time (in seconds) spent with the agent before getting tickets is a continuous random variable, X, with PDF given by:
  $$f_X(x) = \frac{c}{\sqrt{x}}, \qquad 10 \le x \le 100$$
  where X is measured in seconds. (You need to determine the value of c.)
- For a caller who is put on hold, let Y be the amount of time it takes an agent to become available. Y is an exponential variable with average wait time of 100 seconds.
- The caller will wait a maximum of 2 minutes before hanging up. Then it takes 2 seconds to hang up. (This adds to the total time, but they cannot connect to an agent while in the process of hanging up.)
- If a caller hangs up before being connected to an agent, they may call back later. Suppose that a random caller would attempt to call N times (including the first call) before giving up entirely on getting tickets, assuming they do not get tickets on any call. Each call works the same way and is independent of all previous calls. Assume that N is a discrete random variable (measuring the call-persistence of a random caller) with PMF given by:

n	1	2	3	4	5
$P_N(n)$	0.35	0.3	0.25	0.06	0.04

Let W be the total time spent by a caller trying to get tickets, in seconds.

The company wants to know things like: What is the range of possible times spent by a caller? What will be the mean and median time spent? What does the distribution of times look like graphically? What is the probability that a caller ultimately gets tickets?

Project Tasks

Create a computer simulation of the scenario using the language/environment with which the maximum number of group members have prior experience.

Write a report that *includes* the elements listed below. (You should not simply provide a list of "answers" to the prompts below.) Write it in a self-contained way, so that somebody from outside our class can understand what you have done without reference to this instructions document. Imagine that the ticketing agency is your client, and you are their consultant.

a) An introduction to the scenario that includes an outline of the rest of your report.

b) A detailed tree diagram for the calling process.

c) A written summary of the logic of your simulation. This summary should not rely on any coding syntax.

d) The range of values for W, i.e. the theoretical minimum and maximum values.

   (Note: This does not come from your simulation, although your simulation's results should be consistent with it.)

e) Estimates for the mean and median of W, and the probability that a caller gets tickets in the end.

f) An estimate and graph of the CDF of W.

   (To make these, estimate $F_W(w)$ for fifty equally spaced values of w within your range of possible values. Give these values in a table and as a graph.)

g) A histogram of your values for W, with well-chosen bins, showing the shape of the distribution.

h) You should notice one or more spikes in your histogram. Give the value(s) where the spike(s) occur and give an explanation for what is causing them.

   (Tip: To identify the spikes, temporarily increase the number of bins in your histogram by a lot. This will make for a bad-looking histogram, so don't use it in your report, but it will help you see the spikes better.)

Rules

1. You will work with your (updated) Small Group team and submit one report per team.
2. Every team member must be prepared to discuss and explain any part of the final submitted code and be able to run the code and reproduce the results without assistance.
3. Your code should be submitted at the **end of the report in an appendix**. Your explanations in the main report should not refer to the literal code, but instead should use bullet points (or similar) to succinctly convey the steps of your simulation process.
4. After submission, teams will complete a peer-assessment form which will inform their overall projects participation grade component.
5. **You may not collaborate with anyone else or use any external resources** other than looking up coding documentation as needed. You may ask the instructor for guidance.
6. **You may not use any AI/ML tools in any way for this project.**
7. Your report should be written with professional English and have a clear structure.
8. The last item of the report must be the honor pledge below, and each team member must sign their name under the honor pledge. (Digital signature is allowed.)

   "I have neither given nor received aid on this project, except from authorized sources."

Rubric

Project reports will be graded with the following rubric out of 100:

35 – Correctness of simulation procedure and code
30 – Correctness of estimated data
20 – Clarity of explanations, figures, tables
10 – Code commenting (should be brief and precise)
5 – Professional standards (formatting, figures, English)