

University of Niagara Falls, Canada
Master of Data Analytics
DAMO600 Prescriptive Analytics
Spring 2025
Assignment 2

LO1: Design simulation model using Monte Carlo simulation.

LO2: Develop software solutions using Excel and Python libraries for decision making using simulation.

LO3: Evaluate the performance of operational systems using key performance indicators.

Business Challenge: Cooling Fan Replacement Policy Evaluation in a Data Center Using Simulation

A data center relies on a critical server rack that is cooled by three identical cooling fans. The lifetimes of the fans follow the same probability distribution, as specified in Table 1. When a fan fails, the server shuts down, triggering the dispatch of a repair technician. The technician's arrival delay is a random variable with the probability distribution provided in Table 2. The cost and time associated with fan repairs are as follows

- The cost of each fan is \$32
- The server downtime cost is \$10 per minute.
- The technician's labour cost is \$30 per hour.
- Replacement times are:
 - 1 fan: 20 minutes
 - 2 fans: 30 minutes
 - 3 fans: 40 minutes

A proposed policy suggests replacing all three fans whenever any single fan fails, in order to reduce the frequency of future breakdowns and interruptions.

Management would like to evaluate both policies using a Monte Carlo simulation to estimate the cost implications of servicing 45 fan failures.

Tasks

(a) Simulation Model Design in Excel

(8 marks)

- Design two separate Monte Carlo simulation models in Excel:
 1. Current Policy: Replace only the failed fan.
 2. Proposed Policy: Replace all three fans whenever one fails.
- Simulate the replacement process for 45 fan failure.
- Calculate and compare the total replacement cost under each policy, accounting for both downtime and repair labor.

(b) Python Script for Monte Carlo Simulation

(8 marks)

- Write a Python script to simulate both replacement policies using the Monte Carlo method.
- Run simulations for 45 fan replacements and calculate the total cost for each policy.

Ensure your script includes random generation of failure times and technician delays and calculation of downtime and labor cost

(c) Recommendation to Management

(4 marks)

Based on your simulation results, provide a clear and concise recommendation to management regarding which policy should be adopted.

Table 1: probability distribution of the operational life of cooling fans

Cooling fan Life (hrs.)	Probability
1000	0.1
1100	0.13
1200	0.25
1300	0.13
1400	0.09
1500	0.12
1600	0.02
1700	0.06
1800	0.05
1900	0.05

Table 2: Probability distribution of the technician arrival time

Technician arrival time (min.)	Probability
20	0.60

30	0.30
45	0.10