CST-305 Project 7: Code Errors and Queueing Theory

# 1. Cover Page

Course: CST-305 - Numerical Methods for Engineers

Project Title: Code Errors and Queueing Theory

Semester: Summer 2025

Institution: Grand Canyon University

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# 2. Responsibilities and Completed Tasks.

* Designed and implemented the Lorenz system visualization.
* Developed the queueing theory analysis for all 5 problems.
* Created interactive controls and plot updates.
* Documented mathematical derivations and integrated code.
* Completed the final README and system testing.

# 3. System Performance Context Description

This project models both chaotic and stochastic behaviors in computational systems. The Lorenz attractor illustrates how tiny differences in starting points can result in vastly different outcomes (the butterfly effect), highlighting sensitivity to initial conditions. The queueing models simulate performance bottlenecks in computer networks and processing systems.

# 4. Specific Problems Solved

Part 1:

* Simulated the Lorenz system for two initial conditions to visually demonstrate divergence over time.

Part 2:

* Problem 1: FCFS queue analysis.
* Problem 2: M/M/1 system with buffer overflow.
* Problem 3: Scaling analysis.
* Problem 4: Max arrival rate under delay constraint.
* Problem 5: TCMP model visualization.

# 5. Mathematical Approach

* Lorenz: 3 coupled nonlinear ODEs, solved with scipy.integrate.odeint.
* Queueing:
* FCFS: Manual wait time and queue length calculations.
* M/M/1: Steady-state probability and delay formulas.
* Scaling: Throughput, utilization, expected delay.
* Max λ: Solve E[Tq] < 6 for max ρ and λ.
* TCMP: Branching probability model.

A diagram of a computer

AI-generated content may be incorrect.

# 6. Code Implementation Approach

* Lorenz: Defined equations, solved with odeint, plotted in 3D with sliders.
* Queueing: Each problem in its method; used line/bar charts for visualization.

# 7. Screenshots of Key Phases

Check Screenshots Docx

* Lorenz 3D plot with two trajectories.
* X-difference log plot.
* Queue timeline plots.
* M/M/1 scaling analysis.
* TCMP model diagram.

# 8. References

* Lorenz, E. N. (1963). "Deterministic nonperiodic flow". Journal of the Atmospheric Sciences.
* Kleinrock, L. (1975). Queueing Systems, Volume 1. Wiley.
* Matplotlib Docs
* SciPy Docs
* GCU CST-305 course materials.