README: Water Bottle Manufacturing Simulation with SimPy

# 📋 Project Overview

This simulation models a water bottle manufacturing process using SimPy, including:  
1. Blow Molding  
2. Cleaning  
3. Filling  
4. Capping & Labeling  
5. Packaging  
  
The simulation supports:  
✅ Deterministic and stochastic demand  
✅ Deterministic and stochastic processing times  
✅ Single-run and multiple-run/replication simulations for performance analysis.

# 🚀 Project Structure

/project-folder/  
├── config.py # Configuration file for simulation parameters  
├── process.py # Manufacturing process class definition  
├── manufacturing\_simulation.py # Main simulation file (single run)  
├── manufacturing\_simulation\_replication.py # Simulation with multiple replications  
└── README.docx # This guide (Word format)

# 🛠 Installation & Setup

1️⃣ Install Required Libraries  
Ensure you have Python 3.7+ installed. Run the following command:  
  
pip install simpy numpy  
  
2️⃣ Configure Simulation Parameters (`config.py`)

# 🎬 Running the Simulation

✅ Single Run Simulation:  
Run the single-run simulation using:  
  
python manufacturing\_simulation.py  
  
✅ Multiple Runs Simulation (Replications):  
Run the multiple-run simulation using:  
  
python manufacturing\_simulation\_replication.py

# 📈 Understanding the Output

Single Run Output:  
- Total Bottles Produced  
- Throughput (bottles/hour)  
- Average and Maximum Queue Length  
- Machine Utilization per stage  
  
Multiple Runs Output (Replications):  
- Mean and Standard Deviation for Total Bottles Produced, Throughput, Queue Lengths, and Machine Utilization.

# 🔄 Customizing the Simulation

1️⃣ Change Demand Characteristics:  
- Deterministic: DEMAND\_RATE = 5  
- Stochastic: DEMAND\_RATE = lambda: random.expovariate(1/5)  
  
2️⃣ Modify Processing Times:  
- Fixed times: PROCESS\_TIMES = [5, 3, 2, 4, 5]  
- Stochastic times: Adjust lambda functions in config.py.  
  
3️⃣ Adjust Number of Replications:  
NUM\_REPLICATIONS = 10 # Modify this number for more or fewer runs.

# 💡 Notes & Best Practices

- Set a random seed for reproducibility: random.seed(42)  
- Experiment by adjusting SIM\_TIME, MACHINE\_CAPACITIES, and CONVEYOR\_CAPACITIES.

# 💬 Troubleshooting

1. ModuleNotFoundError:  
 - Ensure Python is in PATH.  
 - Run pip install simpy numpy.  
  
2. Stochastic Results Vary Widely:  
 - Increase the number of replications for stable averages.  
  
3. Performance Issues:  
 - Reduce SIM\_TIME or simplify stochastic functions.

# 🙌 Contributors

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# 📜 License

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