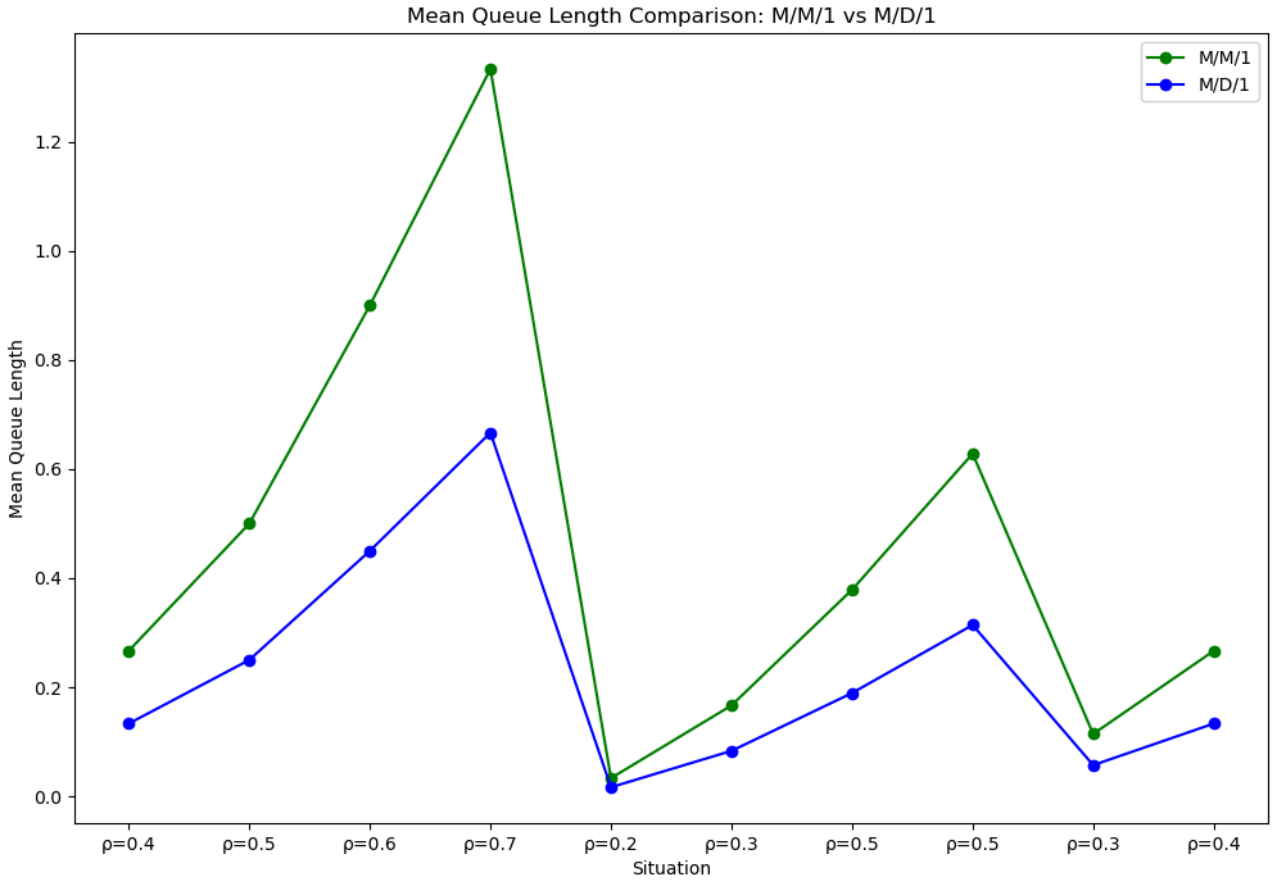
Question-1:

Code :

mean-lenght-comparision.py

```python
import numpy as np
import matplotlib.pyplot as plt

situations = [
  (0.2, 0.5),
  (0.4, 0.8),
  (0.6, 1.0),
  (0.8, 1.2),
  (0.1, 0.6),
  (0.3, 0.9),
  (0.5, 1.1),
  (0.7, 1.3),
  (0.2, 0.7),
  (0.4, 1.0)
]

mm1_queue_lengths = []
md1_queue_lengths = []

for lmd, mu in situations:
  rho = lmd/mu

  # M/M/1 queue length
  mm1_queue_length = (rho*rho) / (1-rho)
  mm1_queue_lengths.append(mm1_queue_length)

  # M/D/1 queue length (assuming Constant service time distribution)
  md1_queue_length = (rho*rho) / (2*(1-rho))
  md1_queue_lengths.append(md1_queue_length)

fig, ax = plt.subplots(figsize=(12, 8))
x = np.arange(len(situations))
ax.plot(x, mm1_queue_lengths, '-o', color='green', label='M/M/1')
ax.plot(x, md1_queue_lengths, '-o', color='blue', label='M/D/1')
ax.set_xticks(x)
# ax.set_xticklabels([f"λ={lmd}\nμ={mu}" for lmd, mu in situations])
ax.set_xticklabels([f"ρ={(lmd/mu):.1f}" for lmd, mu in situations])
ax.set_xlabel('Situation')
ax.set_ylabel('Mean Queue Length')
ax.set_title('Mean Queue Length Comparison: M/M/1 vs M/D/1')
ax.legend()
plt.show()
```

Output:



Question-2 b:

Toll booths are a real-world example of an M/G/S queuing system.

Vehicles arrive at the toll booth according to a Poisson process, meaning the arrival of vehicles follows a random, memoryless pattern.

The service times, which represent the time it takes to process each vehicle through the toll booth, can have a general probability distribution, such as a Weibull distribution. This is due to the variability in payment methods used by drivers (cash, electronic toll collection, etc.) and the fluctuations in traffic flow, which can affect the time required to complete the toll transaction.

To handle this flow of vehicles, multiple toll booths or servers are available, representing the S in the M/G/S notation.