HW3/4
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1. To run simulator, run MM1simulator file (Main method generates output)

   a. $\lambda = 5, T_s = 0.15$

   Analytical Results: Simulation Results
   $T_w = 0.45$
   $q = 3$
   $\rho = 0.75$

   ```
   Beginning MM1 Simulation: (5,0.15,100000) ...
   Results:
    Average Wait Time (Tw): 0.454889
    Average Queuing Time (Tq): 0.605079
    Average # in Queue (w): 2.274285
    Average # in System (q): 3.026256
    Utilization (p): 0.751971
   ```

   b. $\lambda = 6, T_s = 0.15$

   Analytical Results:
   $T_w = 1.35$
   $q = 9$
   $\rho = 0.9$

   ```
   Beginning MM1 Simulation: (6,0.15,100000) ...
   Results:
    Average Wait Time (Tw): 1.360245
    Average Queuing Time (Tq): 1.510309
    Average # in Queue (w): 8.176665
    Average # in System (q): 9.078596
    Utilization (p): 0.901931
   ```

   c. $\lambda = 6, T_s = 0.15$

   Analytical Results:

   $T_w = N/A$
   $q = N/A$
   $\rho = 1.2$

   ```
   Beginning MM1 Simulation: (6,0.2,100000) ...
   Results:
    Average Wait Time (Tw): 24871.905369
    Average Queuing Time (Tq): 24872.105157
    Average # in Queue (w): 149069.666215
    Average # in System (q): 149070.666215
    Utilization (p): 1.000000
   ```

2. To run simulator, run MM1Ksimulator file (Main method generates output)

    a. $\lambda = 5, T_s = 0.15, K = 2$

       Analytical Results: Simulation Results

```
Beginning MM1K Simulation: (5,0.15,2,100000) ...
Results:
 Average Wait Time (Tw): 0.064320
 Average Queuing Time (Tq): 0.214337
 Average # in Queue (w): 0.243163
 Average # in System (q): 0.809466
 Utilization (p): 0.566304
 Rejection Probability: 0.244080
```

       $T_q = 0.21315$
       $P(rejection) = 0.24$
       $\rho' = 0.57$

    b. $\lambda = 6, T_s = 0.15, K = 2$

       Analytical Results:

       $T_q = 0.21828$
       $P(rejection) = 0.29$
       $\rho' = 0.639$

```
Beginning MM1K Simulation: (6,0.15,2,100000) ...
Results:
 Average Wait Time (Tw): 0.071126
 Average Queuing Time (Tq): 0.221238
 Average # in Queue (w): 0.299669
 Average # in System (q): 0.931694
 Utilization (p): 0.632026
 Rejection Probability: 0.299373
```

    c. $\lambda = 6, T_s = 0.2, K = 2$

       Analytical Results:

       $T_q = 0.3088$
       $P(rejection) = 0.3956$
       $\rho' = 0.7253$

    d. $\lambda = 5, T_s = 0.15, K = 4$

       Analytical Results:

       $T_q = 0.3223$
       $q = 1.4443$
       $P(rejection) = 0.10371$
       $\rho' = 0.6722$

```
Beginning MM1K Simulation: (6,0.2,2,100000) ...
Results:
 Average Wait Time (Tw): 0.109179
 Average Queuing Time (Tq): 0.309405
 Average # in Queue (w): 0.395568
 Average # in System (q): 1.121546
 Utilization (p): 0.725978
 Rejection Probability: 0.396247
```

```
Beginning MM1K Simulation: (5,0.15,4,100000) ...
Results:
 Average Wait Time (Tw): 0.171329
 Average Queuing Time (Tq): 0.321021
 Average # in Queue (w): 0.765917
 Average # in System (q): 1.436222
 Utilization (p): 0.670305
 Rejection Probability: 0.102394
```

e. $\lambda = 6, T_s = 0.15, K = 4$

Analytical Results:

$T_q = 0.3553$
$P(rejection) = 0.160215$
$\rho' = 0.7558$

```
Beginning MM1K Simulation: (6,0.15,4,100000) ...
Results:
 Average Wait Time (Tw): 0.204991
 Average Queuing Time (Tq): 0.354899
 Average # in Queue (w): 1.032693
 Average # in System (q): 1.787899
 Utilization (p): 0.755206
 Rejection Probability: 0.159394
```

f. $\lambda = 6, T_s = 0.2, K = 4$

Analytical Results:
$T_q = 0.5451$
$P(rejection) = 0.2786$
$\rho' = 0.8656$

```
Beginning MM1K Simulation: (6,0.2,4,100000) ...
Results:
 Average Wait Time (Tw): 0.345227
 Average Queuing Time (Tq): 0.545411
 Average # in Queue (w): 1.493638
 Average # in System (q): 2.359194
 Utilization (p): 0.865556
 Rejection Probability: 0.278678
```

g. $\lambda = 5, T_s = 0.15, K = 10$

Analytical Results:

$T_q = 0.5105$
$P(rejection) = 0.0147$
$\rho' = 0.7389$

h. $\lambda = 6, T_s = 0.15, K = 10$

Analytical Results:

```
Beginning MM1K Simulation: (5,0.15,10,100000) ...
Results:
 Average Wait Time (Tw): 0.364814
 Average Queuing Time (Tq): 0.515245
 Average # in Queue (w): 1.796502
 Average # in System (q): 2.537070
 Utilization (p): 0.740568
 Rejection Probability: 0.014947
```

$T_q = 0.6969$
$P(rejection) = 0.0508$
$\rho' = 0.8543$

```
Beginning MM1K Simulation: (6,0.15,10,100000) ...
Results:
 Average Wait Time (Tw): 0.546232
 Average Queuing Time (Tq): 0.696291
 Average # in Queue (w): 3.107882
 Average # in System (q): 3.960751
 Utilization (p): 0.852869
 Rejection Probability: 0.050692
```

i. $\lambda = 6, T_s = 0.2, K = 10$

Analytical Results:

$$T_q = 1.3865$$
$$P(rejection) = 0.1926$$
$$\rho' = 0.968$$

```
Beginning MM1K Simulation: (6,0.2,10,100000) ...
Results:
 Average Wait Time (Tw): 1.191548
 Average Queuing Time (Tq): 1.391760
 Average # in Queue (w): 5.772317
 Average # in System (q): 6.742540
 Utilization (p): 0.970224
 Rejection Probability: 0.193474
```

3. $\mu = 3 \quad n = 40 \quad \alpha = 0.04$

a.

$$0.4 = 2.05 \, \frac{\sigma}{\sqrt{40}}$$

$$1.23406 = \sigma$$

b.
$$Z = 2.57$$

c.
$$0.1 = 2.05 \, \frac{1.23406}{\sqrt{n}}$$
Sample size should be at least 641.