Assignment (Queueing)

1. Consider an $M/M/1$ queue having $\lambda = 3$ arrivals per minute and $\mu = 4$ customers per minute. Compute the following steady-state quantities.
   (a) the proportion of time during which three customers are in the system [0.1054]
   (b) the average number of customers in the system [3]
   (c) the average amount of time a customer spends in the system [1]
   (d) the average amount of time a customer spends waiting in the queue [0.75]
   (e) the average number of customers in the queue [2.25]
   (f) the average number of customers in the service [0.75]
   (g) the proportion of arriving customers who finds three customers in the system [0.1054]
   (h) the proportion of departing customers who leave three customers in the system [0.1054]
   (i) the proportion of time that the server is busy [0.75]

2. Consider an $M/M/1/3$ queue having $\lambda = 3$ arrivals per minute and $\mu = 4$ customers per minute. Compute the following steady-state quantities.
   (a) the proportion of time during which three customers are in the system [0.1542]
   (b) the average number of customers in the system [1.149]
   (c) the average amount of time a customer spends in the system [0.4528]
   (d) the average amount of time a customer spends waiting in the queue [0.202]
   (e) the average number of customers in the queue [0.514]
   (f) the average number of customers in the service [0.635]

3. Consider an $M/M/3$ queue having $\lambda = 10$ arrivals per minute and $\mu = 4$ customers per minute. Compute the following steady-state quantities.
   (a) the probability that the system is empty [0.044]
   (b) the probability that an arriving customers who finds two customers in the system [0.1375]
   (c) the probability that an departing customers leaves six customers in the system [0.066]
   (d) the average number of customers in the queue [3.4375]
   (e) the average amount of time a customer spends waiting in the system [0.5885]
   (f) the average number of customers in the system [5.885]
   (g) the average number of idle servers [0.5525]

4. Consider an $M/M/2/5$ queue having $\lambda = 6$ arrivals per hour and $\mu = 9$ customers per hour. Compute the following steady-state quantities.
   (a) the proportion of time during which there are five customers are in the system
   (b) the average number of customers in waiting for service [0.0740]
   (c) the average number of busy servers [0.664]
   (d) the average number of customers in the system [0.738]
   (e) the average amount of time a customer spends in the system [0.1235]
   (f) the average amount of time a customer spends waiting in the queue. [0.0123].
   (g) the average number of customers lost per hour
   (h) the average amount of time a customer spends in the system (including customers in balk)