1. Willow Brook National Bank operates a drive-up teller window that allows customers to complete bank transactions without getting out of their cars. On weekday mornings, arrivals to the drive-up teller window occur at random, with a mean arrival rate of 24 customers per hour or 0.4 customer per minute.
   a. What is the mean or expected number of customers that will arrive in a five-minute period?
   b. Assume that the Poisson probability distribution can be used to describe the arrival process. Use the mean arrival rate in part (a) and compute the probabilities that exactly 0, 1, 2, and 3 customers will arrive during a five-minute period.
   c. Delays are expected if more than three customers arrive during any five-minute period. What is the probability that delays will occur?

2. In the Willow Brook National Bank waiting line system (see Problem 1), assume that the service times for the drive-up teller follow an exponential probability distribution with a mean service rate of 36 customers per hour or 0.6 customer per minute. Use the exponential probability distribution to answer the following questions.
   a. What is the probability the service time is one minute or less?
   b. What is the probability the service time is two minutes or less?
   c. What is the probability the service time is more than two minutes?

3. Use the single-channel drive-up bank teller operation referred to in Problems 1 and 2 to determine the following operating characteristics for the system.
   a. The probability that no customers are in the system
   b. The average number of customers waiting
   c. The average number of customers in the system
   d. The average time a customer spends waiting
   e. The average time a customer spends in the system
   f. The probability that arriving customers will have to wait for service

4. Use the single-channel drive-up bank teller operation referred to in Problems 1–3 to determine the probabilities of 0, 1, 2, and 3 customers in the system. What is the probability that more than three customers will be in the drive-up teller system at the same time?

SELF test

5. The reference desk of a university library receives requests for assistance. Assume that a Poisson probability distribution with a mean rate of 10 requests per hour can be used to describe the arrival pattern and that service times follow an exponential probability distribution with a mean service rate of 12 requests per hour.
   a. What is the probability that no requests for assistance are in the system?
   b. What is the average number of requests that will be waiting for service?
   c. What is the average waiting time in minutes before service begins?
   d. What is the average time at the reference desk in minutes (waiting time plus service time)?
   e. What is the probability that a new arrival has to wait for service?

6. Movies Tonight is a typical video and DVD movie rental outlet for home viewing customers. During the weeknight evenings, customers arrive at Movies Tonight at the average rate of 1.25 customers per minute. The checkout clerk can serve an average of two customers per minute. Assume Poisson arrivals and exponential service times.
   a. What is the probability that no customers are in the system?
   b. What is the average number of customers waiting for service?
   c. What is the average time a customer waits for service to begin?
   d. What is the probability that an arriving customer will have to wait for service?
   e. Do the operating characteristics indicate that the one-clerk checkout system provides an acceptable level of service?

7. Speedy Oil provides a single-channel automobile oil change and lubrication service. New arrivals occur at the rate of 2.5 cars per hour and the mean service rate is 5 cars per hour. Assume that arrivals follow a Poisson probability distribution and that service times follow an exponential probability distribution.
   a. What is the average number of cars in the system?
   b. What is the average time that a car waits for the oil and lubrication service to begin?
   c. What is the average time a car spends in the system?
   d. What is the probability that an arrival has to wait for service?

8. For the Burger Dome single-channel waiting line in Section 12.2, assume that the arrival rate is increased to 1 customer per minute and that the mean service rate is increased to 1.25 customers per minute. Compute the following operating characteristics for the new system: P_0, L_q, L, W_q, W, and P_w. Does this system provide better or poorer service compared to the original system? Discuss any differences and the reason for these differences.

9. Marty's Barber Shop has one barber. Customers arrive at the rate of 2.2 customers per hour, and haircuts are given at the average rate of 5 per hour. Use the Poisson arrivals and exponential service times model to answer the following questions.
   a. What is the probability that no units are in the system?
   b. What is the probability that one customer is receiving a haircut and no one is waiting?
   c. What is the probability that one customer is receiving a haircut and one customer is waiting?
   d. What is the probability that one customer is receiving a haircut and two customers are waiting?
   e. What is the probability that more than two customers are waiting?
   f. What is the average time a customer waits for service?

10. Trosper Tire Company decided to hire a new mechanic to handle all tire changes for customers ordering a new set of tires. Two mechanics applied for the job. One mechanic has limited experience, can be hired for $14 per hour, and can service an average of three customers per hour. The other mechanic has several years of experience, can service an average of four customers per hour, but must be paid $20 per hour. Assume that customers arrive at the Trosper garage at the rate of two customers per hour.
    a. What are the waiting line operating characteristics using each mechanic, assuming Poisson arrivals and exponential service times?
    b. If the company assigns a customer waiting cost of $30 per hour, which mechanic provides the lower operating cost?

SELF test

11. Agan Interior Design provides home and office decorating assistance to its customers. In normal operation, an average of 2.5 customers arrive each hour. One design consultant is available to answer customer questions and make product recommendations. The consultant averages 10 minutes with each customer.
    a. Compute the operating characteristics of the customer waiting line, assuming Poisson arrivals and exponential service times.
    b. Service goals dictate that an arriving customer should not wait for service more than an average of 5 minutes. Is this goal being met? If not, what action do you recommend?
    c. If the consultant can reduce the average time spent per customer to 8 minutes, what is the mean service rate? Will the service goal be met?

12. Pete's Market is a small local grocery store with only one checkout counter. Assume that shoppers arrive at the checkout lane according to a Poisson probability distribution, with a mean arrival rate of 15 customers per hour. The checkout service times follow an exponential probability distribution, with a mean service rate of 20 customers per hour.
    a. Compute the operating characteristics for this waiting line.
    b. If the manager's service goal is to limit the waiting time prior to beginning the checkout process to no more than five minutes, what recommendations would you provide regarding the current checkout system?

13. After reviewing the waiting line analysis of Problem 12, the manager of Pete's Market wants to consider one of the following alternatives for improving service. What alternative would you recommend? Justify your recommendation.
    a. Hire a second person to bag the groceries while the cash register operator is entering the cost data and collecting money from the customer. With this improved