

MgtOp 470—Business Modeling with Spreadsheets
TOPIC 5: WAITING LINES AND QUEUING THEORY
Practice Problems

1. Located in the Cougar Union Building, the Bookie is the WSU student book and apparel store. Suppose that only one checkout counter is operational throughout the store's hours. The combination of the cash register and the operator is the server (or service facility) in this waiting line system; the customers who line up at the counter to pay for their selections form the waiting line. After finding products, customers enter the queue system. Suppose customers arrive at a rate of 24 per hour according to a Poisson distribution ($\lambda = 24$), and service times are exponentially distributed, with a mean rate of 30 customers per hour ($\mu = 30$).
 - a) Find the probability that no customers are in the queuing system.
 - b) Find the probability that less than 2 customers are in the queuing system.
 - c) Find the average number of customers in the queuing system.
 - d) Find the average number of customers in the waiting line.
 - e) Find the average time a customer spends in the queuing system.
 - f) Find the average time a customer spends waiting in line to be served.
 - g) Find the probability that an arriving customer has to wait in line.
2. Re-solve question 1 but assume that the average service rate is 1 customer per minute.
3. The Pullman Chevron has an automatic car wash, and customers purchasing gas at the station receive a discounted car wash, depending on the number of gallons of gas they buy. The car wash can accommodate one car at a time, and it takes a constant time of 4 minutes for a wash. If the arrival rate is 12 customers per hour, determine the following:
 - a) Average number of units in the waiting line
 - b) Average number of units in the system
 - c) Average time a unit spends in the waiting line
 - d) Average time a unit spends in the system
4. The Local Bank of Pullman has only has one teller. Suppose the customers arrive at a rate of 40 per hour according to a Poisson distribution. The probability of no customers in the system is 0.5. Find the average number of customers in the waiting line.
5. A student health service has a waiting room in which chairs are placed along a wall, forming a single waiting line. Some students have health problems that only require a nurse. The students are served by three nurses, each located in a separate room. Students are treated on a first-come, first-served basis. A study of the health service shows that an average of 10 students arrive per hour (according to a Poisson distribution), and an average of 4 students can be served per hour by a nurse (Poisson distributed). Find the following operational characteristics.
 - a) Probability that there are no customers in the system where all servers are idle
 - b) Average number of customers in the waiting line
 - c) Average number of customers in the queuing system
 - d) Average time a customer spends waiting in line to be served
 - e) Average time a customer spends in the queuing system