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| EGC_Black | Student Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_    **Eastern G oldfields College**  Mathematics Essentials 2015  Application 2 – Join the Queue  1 |

Notes and Calculator Allowed **TIME:** 90 min  **TOTAL MARKS**: 49

This practical application is worth 8% of your course mark.

**Equipment needed**: calculator, notes, ruler, dice, random number generator, plain paper for working.   
  
These days there are many businesses where it is necessary to queue for service. Supermarkets, banks, fast-food restaurants are some familiar examples. Frequently you will notice that there are ten or more work stations, but only a few of them are used except at busy times. Why?

Still to do:

* Activity 4 – mean table
* To reduce time ~ complete all activity 3 tables (or most)???

It is possible to **simulate** the situation of waiting in queue.

**Activity 1 Quiet Time (6 Marks: 2, 2, 1, 1)**

At a small supermarket it is the “quiet” time; there is one checkout open. Customers are arriving at the checkout at the rate of one per minute. We will assume that it takes two minutes to serve each customer. What is happening to the length of the queue? How long do customers have to wait to be serviced? How can the situation be represented?

1. Complete the following table:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Time (minutes) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| New customers | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Customers served | 0 | 1 | 0 | 1 | 0 | 1 |  |  |  |  |
| Number in queue | 1 | 1 | 2 | 2 |  |  |  |  |  |  |

1. After 10 minutes how many customers are waiting in the queue?
2. How could the store manager improve the situation?
3. What would happen if the customers arrived at the checkout at a different rate?

**Activity 2 Quiet Time Checkout Numbers (23 Marks: 1, 2, 1, 1, 1, 2, 5, 2, 2, 2, 2, 2 )**

At a supermarket checkout, you cannot always guarantee the rate at which customers arrive. In this activity you need to simulate the arrival of customers to the checkout. Where customers are served every 2 minutes and there is up to and including, 6 customers at any one time.

1. What method will you use to simulate the number of new customers that arrive to the checkout per minute?
2. Using your method of simulation and assuming that one customer is served every 2 minutes, the following table was completed.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **One checkout open** |  |  |  |  |  |  |  |  |  |  |
| Time (minutes) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| New customers |  |  |  |  |  |  |  |  |  |  |
| Customers served | 0 | 1 | 0 | 1 | 0 | 1 |  |  |  |  |
| Number in queue |  |  |  |  |  |  |  |  |  |  |

1. Using these results, what is happening to the queue length?
2. Now consider the situation if another checkout was opened. Repeat the simulation for **two checkouts** open and two customers may be served every two minutes, complete the table below.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Two checkouts open** |  |  |  |  |  |  |  |  |  |  |
| Time (minutes) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| New customers |  |  |  |  |  |  |  |  |  |  |
| Customers served | 0 | 2 | 0 | 2 | 0 | 2 |  |  |  |  |
| Number in queue |  |  |  |  |  |  |  |  |  |  |

1. What happened to the queue length, with an extra checkout opened?
2. Should more checkouts be opened? Why/why not?
3. Repeat your simulation for further checkouts opened.   
   1. The rate for the number of customers that can be served every two minutes changes according to the number of checkouts opened. Complete the table below stating the rate of customers that can be served, given the number of checkouts opened.

|  |  |
| --- | --- |
| Number of  Checkouts Open | Rate (number of customers / 2 minutes) |
| 1 | 1 customer / 2 minutes |
| 2 |  |
| 3 |  |
| 4 |  |
| 5 |  |

* 1. Complete the tables below.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Three checkouts open** | | |  |  |  |  |  |  |  |  |
| Time (minutes) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| New customers |  |  |  |  |  |  |  |  |  |  |
| Customers served | 0 | 3 |  |  |  |  |  |  |  |  |
| Number in queue |  |  |  |  |  |  |  |  |  |  |

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| **Four checkouts open** | | |  |  |  |  |  |  |  |  |
| Time (minutes) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| New customers |  |  |  |  |  |  |  |  |  |  |
| Customers served | 0 | 4 |  |  |  |  |  |  |  |  |
| Number in queue |  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Five checkouts open** | | |  |  |  |  |  |  |  |  |
| Time (minutes) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| New customers |  |  |  |  |  |  |  |  |  |  |
| Customers served | 0 | 5 |  |  |  |  |  |  |  |  |
| Number in queue |  |  |  |  |  |  |  |  |  |  |

1. Reviewing all of the simulations for Activity 2, what was the **least** number of checkouts needed for good service? How did you decide?

1. Why is the least number important to the supermarket manger?
2. Explain a limitation of this simulation?
3. Identify one way this simulation is:
   1. similar to a supermarket;
   2. different to a supermarket.
4. List two assumptions that have been made?

**Activity 3 Peak Hour Checkout Numbers (11 Marks: 1, 4, 3, 3)**

It is now peak hour at the simulated supermarket. This means you can up to 12 customers arriving at any one time to a checkout.

1. What method will you use to simulate the number of new customers that arrive to the checkout per minute?
2. Using your method of simulation, complete the table below.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Five checkouts open** | | |  |  |  |  |  |  |  |  |
| Time (minutes) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| New customers | *5* | *6* | *10* | *12* | *2* | *6* | *11* | *7* | *8* | *2* |
| Customers served | 0 | 5 | 0 | 5 | 0 | 5 | 0 | 5 | 0 | 5 |
| Number in queue | *5* | *6* | *16* | *23* | *25* | *26* | *37* | *39* | *47* | *44* |

1. Using the table above, answer the following questions:  
   1. How many customers are left waiting at the end of 10 minutes? \_\_\_\_\_\_\_\_\_\_\_\_\_
   2. How many minutes, does the last customer have to wait to be served? Show your working.
   3. Do you more checkouts need to be opened? \_\_\_\_\_\_\_\_\_\_\_\_\_
2. Repeat the simulation for 6, 7 and 8 checkouts opened.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Six checkouts open** | | |  |  |  |  |  |  |  |  |
| Time (minutes) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| New customers |  |  |  |  |  |  |  |  |  |  |
| Customers served | 0 | 6 |  |  |  |  |  |  |  |  |
| Number in queue |  |  |  |  |  |  |  |  |  |  |

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| **Seven checkouts open** | | |  |  |  |  |  |  |  |  |
| Time (minutes) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| New customers |  |  |  |  |  |  |  |  |  |  |
| Customers served | 0 | 7 |  |  |  |  |  |  |  |  |
| Number in queue |  |  |  |  |  |  |  |  |  |  |

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| **Eight checkouts open** | | |  |  |  |  |  |  |  |  |
| Time (minutes) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| New customers |  |  |  |  |  |  |  |  |  |  |
| Customers served | 0 | 8 |  |  |  |  |  |  |  |  |
| Number in queue |  |  |  |  |  |  |  |  |  |  |

1. Have you reached the minimum number of checkouts open for good customer service? Justify your answer?

**Activity 4 Further Simulations (9 Marks: 4, 2, 3)**

The simulation you ran for Activities 2 and 3 was repeated 10 times and for up to 10 checkouts open. The average for each number of checkouts open was then calculated. The table below has these results.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Mean** number of customers in queue | Number of checkouts open | | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Quiet Time |  |  |  |  |  |  |  |  |  |  |
| Peak Time |  |  |  |  |  |  |  |  |  |  |

NEED TO INSERT NUMBERS INTO TABLE ABOVE!

1. Minimum number of checkouts open required for good service.
   1. Using the mean data, determine the least number of checkouts open for good service.
   2. Compare this answer to your answer in question 19.
2. Why is it important to use the mean data obtained from several simulations when making decisions?

1. Some stores or service providers have a different system to forma a queue to serve customers. Identify a different methods of serving customers in different professions and for each method, explain one advantage and one disadvantage.

Method

Advantage

Disadvantage