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| EGC_Black | Student Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_    **Eastern Goldfields 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?

5

1. How could the store manager improve the situation?

Open more checkouts

1. What would happen if the customers arrived at the checkout at a different rate?

The queue world vary in length, perhaps shorter, perhaps longer. The simulation is not very appropriate case.

**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?

One 6-side di OR number generator in: excel OR calculator

1. Using your method of simulation and assuming that one customer is served every 2 minutes, complete the following table.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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 your results, what is happening to the queue length?

The queue is getting very long very quickly.

1. 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?

The queue is shorter, but still very long.

1. Should more checkouts be opened? Why/why not?

Yes, because the queue is still very long.

1. 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 |  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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?

Answer as per their results

1. Why is the least number important to the supermarket manger?

It is important because he must pay extra wages to employ more people at checkouts.

1. Explain a limitation of this simulation?

* Some minutes no customers could arrive, but the model doesn’t show this.
* Customers do not all take the same time to go through a checkout
* Supermarkets usually have a speedy lane for low number of items.

1. Identify one way this simulation is:
   1. similar to a supermarket;
   2. different to a supermarket.
2. List two assumptions that have been made?

* Customers take the same time to go through a checkout
* All customers arrive within 2 minutes of each other

**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?

Two 6-side di OR number generator in: excel OR calculator

1. 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. Justify why more open checkouts are required.
2. 44 customers
3. 44 customers waiting at a rate of 5 served every 2 minutes means the 44th customer must wait 17.6 minutes.
4. Yes, The queue is unacceptably long at the end of 10 minutes
5. 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 |  |  |  |  |  |  |  |  |  |  |

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

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **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?

Students need to consider what an “acceptable wait” is.

**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?  
     
   Because simulations are unpredictable by design, some distorted results might lead to an inappropriate decision. By averaging the results, decisions can be made on a more reliable basis.
3. 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 1

Making appointment (eg doctor, hair dresser, etc)

Advantage

Less waiting time, usually

Disadvantage

Inefficient if appointments go overtime

Method 2

Taking a ticket – eg deli, food orders

Advantage

Prevents queue jumpers

Disadvantage

Customers can do other activities (look at purchasing something else) while waiting in queue