

Fall 2016 CX 4010 Assignment 2 Literature Survey

It was determined that, for our simulation with a single queue/server and interarrival time of 20 minutes, the approximate waiting time would be ten minutes. This was determined by using Kingsman's formula<sup>1</sup>, which is shown in Equation 1.

$$T_q = \left( \frac{u}{1-u} \right) \left( \frac{c_a^2 + c_e^2}{2} \right) * t_e$$

**Equation 1.** Kingsman's formula calculation of time in queue from  $u$  ("traffic"<sup>2</sup>, or interarrival rate divided by service rate),  $c_a$  and  $c_e$ , coefficients of variation, and  $t_e$ , the mean processing time.

In our implementation, the traffic was defined to be 0.5 (unitless), calculated from the arrival rate of 3 units per hour divided by the service rate of 6 units per hour. Both coefficients of variation were 1 (unitless), as the arrival and processing time of the units was an exponential function<sup>3</sup>. Finally, the mean processing time was defined to be 10 minutes. These values are substituted into Kingsman's equation, seen below in Equation 2.

$$T_q = \left( \frac{0.5}{1-0.5} \right) * \left( \frac{1+1}{2} \right) * 10 \text{ minutes} = 1 * 1 * 10 \text{ minutes} = 10 \text{ minutes}$$

**Equation 2.** Kingsman's equation with the proper values for our simulation substituted in.

Equation 2 shows that our simulation's estimated time in queue for an object would be 10 minutes when using an interarrival time of 20 minutes. The results of our simulation are in `singleStation.csv` and `singleStation.xlsx`. Our simulated average time in queue was 11.39 minutes for an interarrival time of 20 minutes, which is roughly what our mathematical model predicted with a 13.9% margin of error. This could be further evaluated with additional runs to see if the mean time in queue over many trials approaches the theoretical mean of 10 minutes.

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<sup>1</sup> Al-Fuqaha, Ala. "Advanced Queuing." Western Michigan University. Web. 25 Sept. 2016.

<sup>2</sup> Ross, Andrew. "Queueing Theory." Eastern Michigan University. Web. 25 Sept. 2016.

<sup>3</sup> "1.3.6.6.7. Exponential Distribution." *Information Technology Lab*. NIST. Web. 25 Sept. 2016.