

## Solutions of

### **OR 441: Simulation and Modeling Exercises Sheet #2**

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#### **Solution1:**

Potential performance measures include:

- Utilization of the pumps
- Expected number of cars in queue
- Expected waiting time in queue
- Expected number of cars that balk per unit time
- Probability that a car will balk

The point of this question is to have the student contemplate some of the difficulties in actually collecting real data for a simulation.

Collecting the inter-arrival times will be complicated by potential non-stationary arrival patterns. That is, the rate of arrival may vary by the time of day and by day of the week, and potentially the season (summer may have higher rates than winter). If possible a computerized method can be devised (e.g. a car counter based on pulse wire, or a camera system). The pump may allow the collection of the start of pumping and the stopping of pumping or alternatively the number of pump uses, but this does not yield the true arrival rate. It only yields those that use the pump. Thus, those that arrive and balk would be missing. If the times are collected by hand, then enough samples during each possible operating period of the station would need to be obtained. If the rate varied by time of day, then multiple days are required. For example, if Fridays are suspected to be different from other days, then we need to observe multiple Fridays in the sample. If the rate is suspected to vary by season, then it would best to have multiple observations of the seasonal period! Wow that is a lot of time spent collecting data. Alternatively, the computerized pump usage might be able to yield non-stationary adjustment factors. If possible, it is best to get the actual times of arrivals, so that the inter-arrival distribution can be examined. If only counts of arrivals are available, then a Poisson or non-homogeneous Poisson might be used for the arrival process. To collect the service times, you need to clearly demark when service begins and when it ends. For example, does service start when the patron gets out of the car or when the patron lifts the pump handle? A computerized capture of the pump start and stop times may be available, but this does not include other portions of the service time. In addition, the service time might vary significantly if the patron pays with cash, check, credit, etc. These and many other issues should be considered in collecting data for even this simple system.

**Solution2:**

- a) Continuous
- b) Discrete
- c) Discrete
- d) Discrete
- e) Continuous
- f) Discrete
- g) Discrete
- h) Discrete
- i) Continuous

**Solution3:**

See page 11 in the textbook (Rossetti 2016):

- a) To compare
- b) To predict
- c) Stream
- d) (1) inverse transform, (2) convolution, (3) acceptance/rejection

**Solution4:**

False. The statement describes validation, not verification.