Review and Discussion Questions

1. **Why is simulation often called a technique of last resort?**

   Simulation is called a technique of last resort because simulation models are time consuming to build (flow charting, coding, etc.) and do not "guarantee" an optimal solution or indeed any solution. Therefore, it makes sense to investigate other problem-solving methods such as linear programming or waiting line theory before embarking on simulation.

2. **What roles do statistical hypothesis testing play in simulation?**

   A simulation can be looked upon as a test of a hypothesis.

3. **What determines whether a simulation model is valid?**

   The only true test of a simulation is how well the real system performs after the results of the simulation have been implemented. The proof of the pudding is in the eating. Prior to this stage of application, however, the simulation user can certainly evaluate the general validity of the model by comparing its results with past data or simply asking the question: "Is the information I am getting reasonable?"

4. **Must you use a computer to get good information from a simulation? Explain**.

   A computer is a must for any but the simplest simulation problems. Because simulation is a sampling process, it stands to reason that a large number of observations is desirable, and the computer is the only practical way of providing them. Of course, computerization is no guarantee of "good" information. Simulating an invalid model on the computer will only provide a larger volume of questionable data.

5. **What methods are used to increment time in a simulation model? How do they work?**

   Time incrementing methods include fixed time increments and variable time increments. With fixed time increments, uniform clock times are specified (minutes, hours, days, etc.) and the simulation proceeds by fixed intervals from one time period to the next. At each point in clock time, the system is scanned to determine if any events have occurred and time is advanced; if none have, time is still advanced by one unit.

   With variable time increments, the clock time is advanced by the amount required to initiate the next event. It is interesting to note that variable time incrementing generally is more difficult to program unless one is using a special simulation language such as GPSS.

6. **What are the pros and cons of starting a simulation with the system empty? With the system in equilibrium?**

The pros of starting a simulation with the system empty are that this enables evaluation of the transient period in terms of time to reach steady-state and the activities which are peculiar to the transient period.

One con is that it takes a longer period of time to perform the simulation.
A second is that the model will be biased by the set of initial values selected, since the time to achieve steady- state and the activities which take place during the transient period will be affected by the initial values. Steps must be taken to remove these initial values if steady-state results are needed.

The advantages of starting the system in equilibrium are that the run time may be greatly reduced, and that the aforementioned bias may be eliminated.

The disadvantage of starting the simulation in equilibrium is, in essence, that it assumes that the analyst has some idea of the range of output he is looking for. This, in a sense, constitutes "beating" the model and may lead to incorrect conclusions from the simulation run.

7. **Distinguish between known mathematical distributions & empirical distributions. What information is needed to simulate using a known mathematical distribution?**

A "known mathematical distribution" is one that can be generated mathematically and is amenable to the laws of statistical probability. Examples of such distributions are the normal, binomial, Poisson, Gamma, and hypergeometric.

An empirical distribution is one that is obtained from observing the probability of occurrence of phenomena relating to a specific situation. While it may be possible to define the moment generating function for such distributions, their applicability to other situations is likely to be small.

The information required to simulate using a known distribution, of course, depends on the known distribution selected. Generally speaking, however, at a minimum, the analyst must be able to estimate the mean and standard deviation of the population to be sampled since they are parameters of distributions.

8. **What is the importance of run length in simulation? Is a run of 100 observations twice as valid as a run 0f 50?**

The length of the simulation run generally determines how much confidence one may have in the results generated by the model. Since simulation is in a large measure a sampling process, it stands to reason that the larger the sample (i.e., the longer the simulation run) the more representative the findings. One the other hand, the selection of variables and parameters for a simulation study represent major sources of potential error and simply running a simulation for a long period of time will not overcome inaccuracies introduced through these factors.

A run of 100 may be twice as good as a run of 50, it may be 10 times as good, or may simply be no better. It depends on the size of the model, the nature of the distributions selected, the stream of random numbers used, and the objective of the study.