Answers are in blue.

# For Exercises 1–8, match the kind of simulation with the example.



**Computer Science Illuminated, Seventh Edition**

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**CHAPTER 14**

EXERCISES AND ANSWERS

1. **Continuous simulation**
2. **Discrete-event simulation**
   1. Weather forecasting A
   2. Stock portfolio modeling B
   3. Seismic exploration A
   4. Hurricane tracking A
   5. Predicting number of tellers a new bank needs B
   6. Determining the number of waiting rooms necessary for a doctor’s office

## B

* 1. Gas exploration A
  2. Air pollution movement A

# For Exercises 9–24, mark the answers true and false as follows:

* + 1. **True**
    2. **False**
  1. Simple systems are best suited to being simulated. B
  2. Complex systems are dynamic, interactive, and complicated. A
  3. A model is an abstraction of a real system. A
  4. The representation of a model may be concrete or abstract. A
  5. In computer simulations, the models are concrete. B
  6. The more characteristics or features represented in the model, the better.

## B

* 1. Continuous simulations are represented by entities, attributes, and events.

## B

* 1. Changes in discrete event simulations are represented by partial differential equations.

## B

* 1. CAD stands for *computer-aided drafting*. B
  2. A time-driven simulation can be thought of as a big loop that executes a set of rules for each value of the clock.

## A

* 1. A model whose realization is within a computer program is an abstract model.

## A

* 1. A concrete model can be realized within a computer program. B
  2. Red is the specular highlight on a green plastic ball, if the light source is red.

## A

* 1. A commonly used illumination model in computer graphics was developed in the 1970s.

## A

* 1. Ambient light, diffuse reflection, and specular reflection are three components of a common shading model for com- puter graphics.

## B

* 1. Computer graphics relies on research from other scientific fields for equations used in image creation.

B

# Exercises 25–52 are problems or short-answer questions.

* 1. Define simulation and give five examples from everyday life. Simulation is the development of a model of a complex sys- tem and the experimentation with the model to observe the results. TV weather forecasters use computer models to predict the weather. Pilots spend time in a flight simulator before actu- ally flying an aircraft. Engineers use wind tunnels to test out a new design. Automotive engineers use simulated crash tests to see how cars survive at different speeds. Dummies are used in crash tests to see how they survive. A chef experiments with a new recipe to see which combination of ingredients is best.
  2. What is the essence of constructing a model?

The essence of constructing a model is to identify a small subset of characteristics or features that are sufficient to describe the behavior to be investigated.

* 1. Name two types of simulations and distinguish between them.

Continuous simulation treats time as continuous and expresses changes in terms of a set of differential equations that reflect the relationships among the set of characteristics. Discrete- event simulation is made up of entities, attributes, and events, where entities represent objects in the real system, attributes are characteristics of a particular entity, and events are interac- tions among entities.

* 1. What are the keys to constructing a good model?

The keys to constructing a good model are correctly choos- ing the entities to represent the system and correctly deter- mining the rules that define the results of the events.

* 1. What defines the interactions among entities in a discrete- event simulation?

A set of rules that are part of the model determine the inter- actions among the events.

* 1. What is the relationship between object-oriented design and model building?

Abstract models are implemented in a computer program, so object-oriented design techniques can be used to build the model.

* 1. Define the goal of a queuing system.

The goal of a queuing system is to determine how to mini- mize wait time.

* 1. What are the four necessary pieces of information needed to build a queuing system?

The four necessary steps are:

* The number of events and how they affect the system (to determine the rules of entity interaction)
* The number of servers (entities)
* The distribution of arrival times (to determine if an entity enters the system)
* The expected service time (to determine the duration of an event)
  1. What part does a random number generator play in queuing simulations?

The random number generator is used to represent luck. If an event happens every *x* minutes, a random number gen- erator is used to determine if the event happens at each minute.

* 1. Write the rules for a queuing simulation of a one-pump gas station, where a car arrives every three minutes and the ser- vice time is four minutes.

If a car arrives, it gets in line. A car arrives if the random num- ber is between 0.0 and 0.33.

If the pump is free and there is a car waiting, the first car in line leaves the line and goes to the pump and the service time is set to four.

If a car is at the pump, the time remaining for the car is decremented.

If there are cars in line, the additional minute that they have been waiting is recorded.

* 1. Do you think the gas station in Exercise 34 will be in business very long? Explain.

No. The service time is greater than the arrival probability.

* 1. Rewrite the simulation in Exercise 34 such that a car arrives every two minutes and the service time is two minutes.

If a car arrives, it gets in line. A car arrives if the random num- ber is between 0.0 and 0.5.

If the pump is free and there is a car waiting, the first car in line leaves the line and goes to the pump and the service time is set to two.

If a car is at the pump, the time remaining for the car is decremented.

If there are cars in line, the additional minute that they have been waiting is recorded.

* 1. Write the rules for a queuing system for an airline reservation counter. There is one queue and two reservation clerks. Peo- ple arrive every three minutes and take three minutes to be processed.

If a customer arrives, he or she gets in line. A customer arrives if the random number is between 0.0 and 0.33.

If a clerk is free and there is a person waiting, the first person in line leaves the line and goes to the free clerk and the ser- vice time is set to three.

If a customer is with the clerk, the time remaining for the cus- tomer is decremented.

If there are customers in line, the additional minute that they have been waiting is recorded.

* 1. Distinguish between a FIFO queue and a priority queue. Deque in a FIFO queue returns the entity that has been in the queue the longest time. Deque in a priority queue returns the entity with the highest priority.
  2. What did SIMULA contribute to object-oriented program- ming methodology?

SIMULA introduced the concepts of classes and objects, inheritance, and polymorphism.

* 1. In general, meteorological models are based on the time- dependent equations of what fields?

Meteorological models are based on time-dependent equa- tions from fluid mechanics and thermodynamics.

* 1. How much mathematics is necessary to be a meteorologist? Five college courses in the calculus sequence plus a course or two in numerical methods should provide the background to understand the mathematics involved in these models.
  2. Why is their more than one weather prediction model? Different models exist because different assumptions are possible.
  3. Why do different meteorologists give different forecasts if they are using the same models?

Meteorologists may or may not agree with the predictions from a particular model. Also, various models give conflict- ing information. Thus, the meteorologist must use their judg- ment as to which, if any, is correct.

* 1. What are specialized meteorological models, and how are the used?

Specialized meteorological models are adaptations for spe- cialized research purposes. A meteorological model may

be combined with air-chemistry models to diagnose atmo- spheric transport and diffusion for a variety of air-quality applications. Specialized meteorological models are useful in the military and aviation industries.

* 1. What are seismic models used for?

Seismic models depict the propagation of seismic waves through the earth’s medium. They are used for oil and min- eral exploration.

* 1. A random number generator can be used to vary service times as well as determine arrivals. For example, assume that 20% of the customers take eight minutes and 80% of the customers take three minutes. How might you use a random number generator to reflect this distribution?

Generate a random number for each customer. If the number is between 0 and .20, the customer takes eight minutes; oth- erwise the customer takes three minutes.

* 1. Why do we say that simulation doesn’t give an answer? Simulation is a tool that allows you to investigate “what if” questions. You can try different values for the parameters of the simulation and see what happens to the wait time.
  2. What do simulations and spreadsheet programs have in common?

Simulations and spreadsheet programs both examine “what if” questions.

* 1. Explain why shadows are important in graphics applications. Shadows are important because they give visual cues as to what is happening in a scene. The location of an object’s shadow or shadows relative to the position of the object itself tells us about where the light source or sources are located. The distance between the object and a shadow

gives us information about the relative position of the object and the location where the shadow is cast. The darkness of the shadow can give us an idea of how close the light source is to the object.

* 1. What type of mathematical objects would you need to use to create a model of a table?

If the top of the table is rectangular, it could be defined by a series of rectangular planes for the top, side, and bottom sur- faces. If the top of the table has rounded corners, planes with rounded corners could be used for the top and bottom. The sides would need a curved surface to create the rounded cor- ners. If the table had square legs, a set of four planes could be used for the sides of each leg. If the table had round legs, a cylinder could be used for each leg. If the table has curved legs, one or more curved surfaces could be used.

* 1. Explain why it is so difficult to get objects to move in com- puter animation.

Object movement must be done very carefully because people are very skilled at recognizing movement. Even the slightest problems will be very noticeable. Physical laws such as gravity can be used for some motion. Motion of figures is more complex because the motion is restricted by how the muscles work and the joints move. When people move, all of their joints are changing position simultaneously. This pro- cess must be duplicated if the resulting animation is going to appear realistic.

* 1. Name five areas encompassed by computational biology. Bioinformatics, computational biomodeling, computational genomics, molecular modeling, and protein structure prediction.