**Multiple Choice Questions**

**Chapter 1: Defining Simulation: What, Why and When?**

1. All simulations involve:
2. The passage of time
3. A model on a computer
4. An imitation of a system
5. A visual display
6. The simulations described in the book are used for:
7. Understanding a system
8. Understanding and improving a system
9. Improving a system
10. None of the above
11. Which of the following is not a simulation method?
12. Monaco simulation
13. System dynamics
14. Agent-based
15. Discrete-event
16. The key reasons for using simulation are that systems are subject to:
17. Variability, interconnectedness and complexity
18. Variability, interconnectedness and simplicity
19. Variability, information and complexity
20. External shocks, interconnectedness and complexity
21. Customers arrive at a service system every 5 minutes and each customer passes through two service points. The service time at both service points is 4.5 minutes. Both the arrival rate and service rate are subject to variability. How long, on average, will it take customers to pass through the system?
22. Less than 9 minutes
23. 9 minutes
24. More than 9 minutes
25. Much more than 9 minutes
26. Which of the following is not a reason to use simulation?
27. It requires a lot of data
28. It is cheaper and quicker than experimenting with the real system
29. It enables the conditions of an experiment to be controlled
30. It fosters a creative approach to improving a system
31. Which of the following systems can be simulated?
32. Transportation systems
33. Manufacturing systems
34. Health systems
35. All of the above

**Chapter 2: Inside Simulation Software**

1. Which of the following is a B-event?
2. Telephone call arrives at a call centre
3. Telephone call answered by an operator
4. Supervisor receives a telephone call forwarded by an operator
5. None of the above
6. Which of the following is a C-event?
7. Telephone call arrives at a call centre
8. Telephone call answered by an operator
9. Telephone call completed by an operator
10. None of the above
11. In the three-phase simulation approach, which of the following best describes the way C-events are handled?
12. Attempt to execute each C-event once
13. Attempt to execute only C-events that relate to the B-event just executed
14. Continue to attempt to execute all C-events until none can be executed
15. Stop the simulation once a C-event has been executed
16. Which of the following is not a discrete-event simulation approach?
17. Three-phase
18. Activity based sampling
19. Process-based
20. Event scheduling
21. The key properties of random numbers are:
22. Uniform and dependent
23. Different and independent
24. Different and dependent
25. Uniform and independent
26. An outcome has a probability of 35% of occurring. To simulate this outcome, which integer random numbers on a scale 00-99 should be associated with it?
27. 00-34
28. 00-35
29. 65-99
30. Any set of 35 unique numbers
31. It is beneficial to generate the same sequence of random numbers in each simulation run because:
32. It saves generating many different sequences of random numbers
33. It enables the same conditions to be repeated over-and-over again
34. The simulation runs faster
35. It removes any variability from the simulation.
36. When sampling from standard statistical distributions, a random number is used to represent:
37. The area under the curve
38. The sample value
39. The height of the curve
40. The skew of the distribution
41. Using the linear congruential random number generator with *Z*0=10, *a*=6, *c*=2 and *m*=80, what is the next random number in the sequence?
42. 52
43. 62
44. 72
45. 82

Chapter 3: Software for Simulation

1. Which of the following is not a benefit of visual interactive simulation?
2. More accurate results
3. Greater understanding of the model
4. Improved communication of the model and its findings
5. Using the simulation in group problem solving
6. A modeller wishes to develop a reasonably, but not overly, complex model. Which type of software is he/she most likely to use?
7. A spreadsheet
8. Specialist simulation software
9. A programming language
10. None of the above
11. Which of the following statements is true?
12. Simulation packages can only model a limited set of applications
13. Simulation packages are rarely used and programming languages are preferred
14. Simulation packages can model most applications within a particular domain
15. Simulation packages can model every application

**Chapter 4: Simulation Studies: An Overview**

1. Which of the following is the key activity in a simulation study?
2. Conceptual modelling
3. Model coding
4. Experimentation
5. All of the above
6. Which of the following is true?
7. The activities in a simulation study are performed in a linear fashion, once one activity is complete the project moves to the next activity.
8. The activities in a simulation study are repeated and frequently iterated between until the study is complete.
9. Once the findings of a simulation study have been implemented, the simulation study is complete.
10. Model coding cannot be started until the conceptual model is completely determined.
11. The duration of a simulation study is typically :
12. Around 1 month
13. Around 3 months
14. More than 6 months
15. All of the above
16. The proportion of time devoted to each activity in a simulation study is typically:
17. 10% conceptual modelling, 80% model coding, 10% experimentation
18. 25% conceptual modelling, 50% model coding, 25% experimentation
19. 33% conceptual modelling, 33% model coding, 33% experimentation
20. 50% conceptual modelling, 20% model coding, 30% experimentation
21. In terms of the roles in a simulation study, which of the following is true?
22. The modeller is sometimes the model user
23. The modeller should always be the model user
24. The modeller should never be the model user
25. The model should only be used by the client
26. What software is likely to be needed for a simulation study?
27. Spreadsheet software
28. Simulation package
29. Statistical software
30. All of the above

**Chapter 5: Conceptual Modelling**

1. Which of the following is not true?
2. A conceptual model describes the objectives of a simulation project
3. A conceptual model describes the scope of a model
4. A conceptual model describes the software that will be used to develop the model
5. A conceptual model does not need to be fully documented
6. Assumptions describe:
7. The simplifications that are incorporated into a simulation model
8. Ways in which uncertainties about the real world are handled in the model
9. The requirements for data collection
10. None of the above
11. When developing a conceptual model it is important to:
12. Abstract to develop a simple model of the real system
13. Model everything that is known about the real system
14. Remove any elements from the model about which there is limited knowledge
15. None of the above
16. When is a conceptual model developed?
17. Before the computer model is developed
18. During development of the computer model
19. After an initial computer model has been developed
20. All of the above
21. Which of the following is not a reason for preferring a simple model?
22. They can be developed faster
23. They require less data
24. They run faster
25. They are always more accurate
26. A conceptual model should be:
27. Valid, incredible, feasible and have utility
28. Verified, credible, feasible and have utility
29. Valid, credible, feasible and have utility
30. Valid, credible, feasible and believable
31. Which of the following is not a means for representing a conceptual model?
32. Component list
33. Activity cycle diagram
34. Pie chart
35. Process flow diagram

**Chapter 6: Developing the Conceptual Model**

1. Conceptual modelling requires the modeller to ... which of the following is not involved?
2. Determine the objectives of the model
3. Identify the model outputs
4. Determine the content of the model
5. Write the model code
6. The modeller can develop the conceptual model by:
7. Talking with the clients
8. Thinking about the problem
9. Using formal methods such as Soft Systems Methodology
10. All of the above
11. The modelling objectives should describe:
12. What needs to be achieved
13. The level of performance that is required
14. Any constraints that need to be worked within
15. If possible, all of the above
16. Which of the following is not a general project objective?
17. Flexibility
18. Model scope
19. Time-scale
20. Ease-of-use
21. Model outputs should:
22. Only report on variables that are relevant to the modelling objectives
23. Report on variables relevant to the modelling objectives and why the objectives are not being achieved
24. Only report on variables that explain why the modelling objectives are not being achieved
25. Report on every aspect of the model
26. The scope of a model can be described in terms of:
27. Entities, activities, queues and resources
28. Entities, activities, queues and processes
29. Entities, services, queues and processes
30. Items, activities, failures and resources
31. In determining the level of detail in a model, which of the following should be done?
32. Choose to exclude key components
33. Fit distributions to data about components of the system
34. Identify any simplifications that are being made
35. All of the above
36. Which of the following are useful methods for model simplification?
37. Black-box modelling
38. Grouping entities
39. Excluding infrequent events
40. All of the above

**Chapter 7: Data Collection and Analysis**

1. Data that are required for developing the computer model are referred to as:
2. Contextual data
3. Data for model realisation
4. Validation data
5. Experimental data
6. Category C data refer to:
7. Data that are available
8. Data that are not available, but collectable
9. Data are that not available and not collectable
10. None of the above
11. A good way to deal with data that are not available is to:
12. Guess their values and hope the results are correct
13. Estimate their values from similar systems
14. Estimate their values and perform a sensitivity analysis
15. Wait until the data become available
16. A key issue in obtaining data is:
17. Ensuring the sample size is sufficient
18. Ensuring the data are in the right format
19. Inspecting the data to check for any inconsistencies
20. All of the above
21. The preferred distribution for modelling customer arrivals is:
22. Negative exponential
23. Log-normal
24. Weibull
25. Normal
26. The preferred distribution for modelling activity times is:
27. Negative exponential
28. Log-normal
29. Erlang
30. Normal
31. The preferred distribution for modelling time between failures is:
32. Log-normal
33. Erlang
34. Normal
35. Weibull
36. The preferred distribution for modelling repair time is:
37. Log-normal
38. Normal
39. Weibull
40. Negative exponential
41. In general, statistical distributions are preferred to traces or empirical distributions because:
42. They make the best use of the random numbers
43. They are an attempt to represent the underlying population distribution
44. They give a high probability of the modal value being sampled
45. They often have long tails
46. Which of the following statistical tests can be used to help determine the fit of a statistical distribution?
47. Chi-square
48. Kolmogorov-Smirnov
49. Anderson-Darling
50. All of the above

**Chapter 8: Model Coding**

1. When designing the model, which of the following need to be considered?
2. The speed of coding
3. The transparency of the code
4. The run-speed
5. All of the above
6. It is best to:
7. Integrate the data into the code of the model
8. Separate the data from the model code using, for example, a spreadsheet
9. Input the data as the model runs
10. None of the above
11. How should the streams of random numbers be used in the model?
12. A separate stream of random numbers should be used for every occasion that random sampling is required
13. The same stream of random numbers should be used throughout the model to ensure consistency
14. No more than ten streams of random numbers should be used in a model
15. A stream of random numbers should be used in at least two places
16. Why should the simulation model be documented?
17. For the modeller to remember how he/she has developed the model
18. Because someone other than the original modeller may need to make changes to the model
19. To help the clients understand the inner workings of the model
20. All of the above

**Chapter 9: Experimentation: Obtaining Accurate Results**

1. The output from a model of a retail bank is most likely to be:
2. Transient
3. Steady-state
4. Steady-state cycle
5. None of the above
6. The output from a model of a factory that makes bricks is most likely to be:
7. Transient
8. Steady-state
9. Steady-state cycle
10. None of the above
11. The output from a model of an airport check-in area is most likely to be:
12. Transient
13. Steady-state
14. Steady-state cycle
15. None of the above
16. How can the initialisation bias in the output of a simulation be dealt with?
17. Running the model for a warm-up period
18. Performing multiple replications
19. Calculating a confidence interval
20. All of the above
21. When should a recommendation by the MSER heuristic for a warm-up period not be used?
22. The value is zero
23. The value is in the first half of the data
24. The value is in the second half of the data
25. None of the above
26. A key problem with setting initial conditions in a model is:
27. Determining appropriate initial conditions
28. Setting-up the conditions in the model
29. Recording the time that initial entities spend in the model
30. All of the above
31. The number of replications should be chosen to:
32. Provide a wide confidence interval
33. Give a high value for the standard deviation
34. Form a confidence interval of a desired precision
35. Give a whole number for the √*n*
36. What is the 95% confidence interval for the mean of the following values: 9.59, 7.50, 13.80, 5.75, 13.67, 7.56, 6.96, 14.44, 7.56, 9.77?
37. 6.97, 10.34
38. 7.37, 11.95
39. 8.23, 12.32
40. 11.01, 14.83
41. When using antithetic variates for variance reduction, how are the model runs treated?
42. Individual runs are treated as individual replications
43. Runs are paired (original and antithetic) and treated as an individual replication
44. There is no need to run more than one original and one antithetic run of the model, since this gives the average performance
45. None of the above
46. Why might a single long run be preferred to running multiple replications?
47. The warm-up period only needs to be run once, reducing the time required to run experiments
48. It ensures independence in the results
49. Confidence intervals can be calculated more easily
50. The estimated mean value is more accurate

**Chapter 10: Experimentation: Searching the Solution Space**

1. The ‘solution space’ is:
2. The best solution to the problem being addressed by the simulation
3. The region that represents all possible combinations of values of the experimental factors
4. The range of outputs that the simulation generates
5. The area that contains the maximum number of solutions to the problem being addressed by the simulation
6. Which of the following is interactive experimentation useful for?
7. Obtaining statistically significant results
8. Understanding the long-run performance of a system
9. Developing an understanding of the system and identifying possible improvements
10. None of the above
11. What is the main problem with generating a confidence interval from a single long run of a simulation model?
12. Obtaining enough data points
13. Removing the initialisation bias
14. Calculating the mean
15. The data points are not independent of one another
16. From the results of 1,000 replications with a simulation model an analyst calculates that the 90th-percentile for the number of units produced in a week is 2,374. How should this result be interpreted?
17. There is a 90 percent probability that less than 2,374 units will be produced in a week
18. There is a 90 percent probability that more than 2,374 units will be produced in a week
19. There is a 90 percent probability that exactly 2,374 units will be produced in a week
20. None of the above
21. A simulation is used to compare two scenarios for a service system: the first with 5 service points and the second with 6. A paired-*t* confidence interval (5% significance level) is calculated for the difference in the mean waiting time for the two scenarios, giving the interval (-0.193, 7.612). What can we conclude from this result?
22. We are 95% confident that, in terms of waiting time, 6 service point is better than having 5
23. We are certain that, in terms of waiting time, 5 service points is the best option
24. We are 95% confident that, in terms of waiting time, there is no difference between the two scenarios
25. We are certain that, in terms of waiting time, there is no difference between the two scenarios
26. A paired-*t* confidence interval should only be used to compare simulation scenarios when:
27. Variance is reduced through the use of common random numbers
28. There is no variance in the simulation output
29. There is a clear difference between the results from the scenarios
30. Multiple replications are being performed with each scenario
31. What is the paired-*t* confidence interval (assume *α* = 0.05) for the difference between the values generated from the following two scenarios?

Scenario A: 9.59, 11.50, 13.80, 9.75, 13.67

Scenario B: 7.56, 6.96, 10.44, 7.73, 8.77

1. -1.91, -0.32
2. -0.73, 2.14
3. 1.69, 5.05
4. 3.61, 8.74
5. A simulation is used to compare the average time in system for 4 scenarios. A pair-wise comparison is performed for each scenario against all the other scenarios using confidence intervals for the difference in mean time in the system. To obtain an overall confidence of 95%, what significance level should be used?
6. 5%
7. 0.5%
8. 1.25%
9. 95%
10. A 2*k* factorial design is used with a simulation of a coffee shop. Two factors are varied between a low and a high level: the number of baristas and the number of service tills. The results are shown in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| **Scenario** | **Number of baristas** | **Number of service tills** | **Waiting time (mins)** |
| 1 | - | - | 2.31 |
| 2 | + | - | 2.09 |
| 3 | - | + | 1.83 |
| 4 | + | + | 1.22 |

What is the main effect of increasing the number of baristas (- to +)?

1. -0.42
2. 0.42
3. 0.68
4. -0.68
5. Having run a series of replications for the four scenarios above, the main effect for increasing the number of service tills is found to be (-0.65, 0.41); expressed as a 95% confidence interval. What does this suggest about the benefit of adding service tills?
6. It seems beneficial to increase the number of service tills
7. It seems beneficial to reduce the number of service tills
8. There seems to be no benefit from additional service tills
9. None of the above
10. Following a series of simulation runs with the above coffee shop model, a multiple regression equation is fitted to the data, giving the following equation:

*w* = 5.31 - 1.04*b* - 0.17*t*

Where:

 *w* = waiting time (mins)

 *b* = number of baristas

 *t* = number of service tills

Using this metamodel, what is the predicted waiting time with 2 baristas and 2 service tills?

1. 5.31
2. 4.22
3. 3.31
4. 2.89
5. Sensitivity analysis is useful for which of the following?
6. Assessing the effect of uncertainties in the data
7. Assessing the robustness of the proposed solution
8. Assessing the effect of changes to the model assumptions
9. All of the above

**Chapter 11: Implementation**

1. Implementation involves which of the following activities?
2. Running simulation experiments
3. Validation of the model
4. Managers learning from a simulation model
5. All of the above
6. For a simulation study to be successful which of the following must be achieved?
7. The study achieves its objectives
8. The findings are implemented
9. Money is saved as a result of the simulation study
10. All of the above
11. Evidence suggests that clients’ perceptions of the quality of a simulation study are primarily based on which of the following?
12. The precision of the confidence intervals that are reported from the model
13. The extent to which the process of delivery of the work meets their expectations
14. The use of statistical methods to validate the model
15. The time taken to complete the study

**Chapter 12: Verification, Validation and Confidence**

1. Verification is:
2. The process of checking the random sampling is correct in the model
3. The process of ensuring that the conceptual model has been satisfactorily transformed into a computer model
4. The process of ensuring that the model is sufficiently accurate for the purpose at hand
5. The process of ensuring the findings are implemented properly
6. Validation is:
7. The process of checking the random sampling is correct in the model
8. The process of ensuring that the conceptual model has been satisfactorily transformed into a computer model
9. The process of ensuring that the model is sufficiently accurate for the purpose at hand
10. The process of ensuring the findings are implemented properly
11. What type of validation is a detailed check of every part of the model?
12. Conceptual model validation
13. White-box validation
14. Black-box validation
15. Solution validation
16. How is confidence in a model created?
17. By proving that it is correct
18. By improving the visual display of the model
19. By using statistical methods to compare the model with the real world
20. By testing the model many times and failing to prove that it is incorrect
21. Which of the following is not a method of white-box validation?
22. Checking that the right distributions have been used for random sampling
23. Expressing the code in a non-technical format and asking the client to check it
24. Stepping through the model event-by-event
25. Setting extreme conditions in the model
26. A model generates the following results from five independent replications that simulation one week: 102.1, 121.3, 119.4, 106.3, 98.5. Meanwhile, the organisation has provided the results from the last five weeks in the real system: 131.4, 102.5, 111.0, 112.9, 121.8. What is the 95% confidence interval for the difference in the means between these results?
27. -12.0, 19.2
28. -22.0, 9.2
29. -31.7, 18.9
30. -21.7, 28.9
31. Would you describe the model in question 6 as valid?
32. Yes
33. No
34. Maybe
35. On some occasions
36. It is important to have a model independently verified and validated:
37. Always
38. Only if it is a very large scale military model
39. On some occasions to help determine if a model is suitable for a particular use
40. Never

**Chapter 13: The Practice of Simulation**

1. Once a simulation model has been developed and used it should be:
2. Thrown-away
3. Reused for another project
4. Used for operational decision-making
5. Could be all of the above
6. When a model is developed without detailed input from the eventual model user, with a view to creating a representation of the real world, this is described as:
7. Simulation as software engineering
8. Simulation as a process of organisational change
9. Simulation as facilitation
10. Simulation as animation
11. When a model is developed and used in a group, with a view to promoting discussion around a real world problem, this is described as:
12. Simulation as software engineering
13. Simulation as a process of organisational change
14. Simulation as facilitation
15. Simulation as animation