ch1

Self-Test

- Before taking the self-test, refer to the learning objectives at the beginning of the chapter, the notes in the margins, and the glossary at the end of the chapter.
- Use the key at the back of the book to correct your answers.
- Restudy pages that correspond to any questions that you answered incorrectly or material you feel uncertain about.

1. In analyzing a problem, you should normally study
   a. the qualitative aspects.
   b. the quantitative aspects.
   c. both a and b.
   d. neither a nor b.
2. Quantitative analysis is
   a. a logical approach to decision making.
   b. a rational approach to decision making.
   c. a scientific approach to decision making.
   d. all of the above.
3. Frederick Winslow Taylor
   a. was a military researcher during World War II.
   b. pioneered the principles of scientific management.
   c. developed the use of the algorithm for QA.
   d. all of the above.
4. An input (such as variable cost per unit or fixed cost) for a model is an example of
   a. a decision variable.
   b. a parameter.
   c. an algorithm.
   d. a stochastic variable.
5. The point at which the total revenue equals total cost (meaning zero profit) is called the
   a. zero-profit solution.
   b. optimal-profit solution.
   c. break-even point.
   d. fixed-cost solution.
6. Quantitative analysis is typically associated with the use of
   a. schematic models.
   b. physical models.
   c. mathematical models.
   d. scale models.
7. Sensitivity analysis is most often associated with which step of the quantitative analysis approach?
   a. defining the problem
   b. acquiring input data
   c. implementing the results
   d. analyzing the results
8. A deterministic model is one in which
   a. there is some uncertainty about the parameters used in the model.
   b. there is a measurable outcome.
   c. all parameters used in the model are known with complete certainty.
   d. there is no available computer software.
9. The term *algorithm*
   a. is named after Algorismus.
   b. is named after a ninth-century Arabic mathematician.
   c. describes a series of steps or procedures to be repeated.
   d. all of the above.
10. An analysis to determine how much a solution would change if there were changes in the model or the input data is called
    a. sensitivity or postoptimality analysis.
    b. schematic or iconic analysis.
    c. futurama conditioning.
    d. both b and c.
11. Decision variables are
    a. controllable.
    b. uncontrollable.
    c. parameters.
    d. constant numerical values associated with any complex problem.
12. _____ is the scientific approach to managerial decision making.
13. _____ is the first step in quantitative analysis.
14. A _____ is a picture, drawing, or chart of reality.
15. A series of steps that are repeated until a solution is found is called a(n) _____.

Discussion Questions and Problems

Discussion Questions

1-1 What is the difference between quantitative and qualitative analysis? Give several examples.

1-2 Define *quantitative analysis*. What are some of the organizations that support the use of the scientific approach?

1-3 What is the quantitative analysis process? Give several examples of this process.

1-4 Briefly trace the history of quantitative analysis. What happened to the development of quantitative analysis during World War II?

1-5 Give some examples of various types of models. What is a mathematical model? Develop two examples of mathematical models.

1-6 List some sources of input data.

1-7 What is implementation, and why is it important?

ch3

Self-Test

- Before taking the self-test, refer to the learning objectives at the beginning of the chapter, the notes in the margins, and the glossary at the end of the chapter.
- Use the key at the back of the book to correct your answers.
- Restudy pages that correspond to any questions that you answered incorrectly or material you feel uncertain about.

1. In decision theory terminology, a course of action or a strategy that may be chosen by a decision maker is called
   a. a payoff.
   b. an alternative.
   c. a state of nature.
   d. none of the above.
2. In decision theory, probabilities are associated with
   a. payoffs.
   b. alternatives.
   c. states of nature.
   d. none of the above.
3. If probabilities are available to the decision maker, then the decision-making environment is called
   a. certainty.
   b. uncertainty.
   c. risk.
   d. none of the above.
4. Which of the following is a decision-making criterion that is used for decision making under risk?
   a. expected monetary value criterion
   b. Hurwicz criterion (criterion of realism)
   c. optimistic (maximax) criterion
   d. equally likely criterion
5. The minimum expected opportunity loss
   a. is equal to the highest expected payoff.
   b. is greater than the expected value with perfect information.
   c. is equal to the expected value of perfect information.
   d. is computed when finding the minimax regret decision.
6. In using the criterion of realism (Hurwicz criterion), the coefficient of realism (α)
   a. is the probability of a good state of nature.
   b. describes the degree of optimism of the decision maker.
   c. describes the degree of pessimism of the decision maker.
   d. is usually less than zero.
7. The most that a person should pay for perfect information is
   a. the EVPI.
   b. the maximum EMV minus the minimum EMV.
   c. the maximum EOL.
   d. the maximum EMV.
8. The minimum EOL criterion will always result in the same decision as
   a. the maximax criterion.
   b. the minimax regret criterion.
   c. the maximum EMV criterion.
   d. the equally likely criterion.
9. A decision tree is preferable to a decision table when
   a. a number of sequential decisions are to be made.
   b. probabilities are available.
   c. the maximax criterion is used.
   d. the objective is to maximize regret.
10. Bayes' theorem is used to revise probabilities. The new (revised) probabilities are called
    a. prior probabilities.
    b. sample probabilities.
    c. survey probabilities.
    d. posterior probabilities.
11. On a decision tree, at each state-of-nature node,
    a. the alternative with the greatest EMV is selected.
    b. an EMV is calculated.
    c. all probabilities are added together.
    d. the branch with the highest probability is selected.
12. The EVSI
    a. is found by subtracting the EMV without sample information from the EMV with sample information.
    b. is always equal to the expected value of perfect information.
    c. equals the EMV with sample information assuming no cost for the information minus the EMV without sample information.
    d. is usually negative.
13. The efficiency of sample information
    a. is the EVSI/(maximum EMV without SI) expressed as a percentage.
    b. is the EVPI/EVSI expressed as a percentage.
    c. would be 100% if the sample information were perfect.
    d. is computed using only the EVPI and the maximum EMV.
14. On a decision tree, once the tree has been drawn and the payoffs and probabilities have been placed on the tree, the analysis (computing EMVs and selecting the best alternative)
    a. is done by working backward (starting on the right and moving to the left).
    b. is done by working forward (starting on the left and moving to the right).
    c. is done by starting at the top of the tree and moving down.
    d. is done by starting at the bottom of the tree and moving up.
15. In assessing utility values,
    a. the worst outcome is given a utility of –1.
    b. the best outcome is given a utility of 0.
    c. the worst outcome is given a utility of 0.
    d. the best outcome is given a value of –1.
16. If a rational person selects an alternative that does not maximize the EMV, we would expect that this alternative
    a. minimizes the EMV.
    b. maximizes the expected utility.
    c. minimizes the expected utility.
    d. has zero utility associated with each possible payoff.

ch4

Self-Test

- Before taking the self-test, refer to the learning objectives at the beginning of the chapter, the notes in the margins, and the glossary at the end of the chapter.
- Use the key at the back of the book to correct your answers.
- Restudy pages that correspond to any questions that you answered incorrectly or material you feel uncertain about.

1. One of the assumptions in regression analysis is that
   a. the errors have a mean of 1.
   b. the errors have a mean of 0.
   c. the observations (Y) have a mean of 1.
   d. the observations (Y) have a mean of 0.
2. A graph of the sample points that will be used to develop a regression line is called
   a. a sample graph.
   b. a regression diagram.
   c. a scatter diagram.
   d. a regression plot.
3. When using regression, an error is also called
   a. an intercept.
   b. a prediction.
   c. a coefficient.
   d. a residual.
4. In a regression model, Y is called
   a. the independent variable.
   b. the dependent variable.
   c. the regression variable.
   d. the predictor variable.
5. A quantity that provides a measure of how far each sample point is from the regression line is
   a. the SSR.
   b. the SSE.
   c. the SST.
   d. the MSR.
6. The percentage of the variation in the dependent variable that is explained by a regression equation is measured by
   a. the coefficient of correlation.
   b. the MSE.
   c. the coefficient of determination.
   d. the slope.
7. In a regression model, if every sample point is on the regression line (all errors are 0), then
   a. the correlation coefficient would be 0.
   b. the correlation coefficient would be -1 or 1.
   c. the coefficient of determination would be -1.
   d. the coefficient of determination would be 0.
8. When using dummy variables in a regression equation to model a qualitative or categorical variable, the number of dummy variables should equal to
   a. the number of categories.
   b. one more than the number of categories.
   c. one less than the number of categories.
   d. the number of other independent variables in the model.
9. A multiple regression model differs from a simple linear regression model because the multiple regression model has more than one
   a. independent variable.
   b. dependent variable.
   c. intercept.
   d. error.
10. The overall significance of a regression model is tested using an F test. The model is significant if
    a. the F value is low.
    b. the significance level of the F value is low.
    c. the r^2 value is low.
    d. the slope is lower than the intercept.
11. A new variable should not be added to a multiple regression model if that variable causes
    a. r^2 to decrease.
    b. the adjusted r^2 to decrease.
    c. the SST to decrease.
    d. the intercept to decrease.
12. A good regression model should have
    a. a low r^2 and a low significance level for the F test.
    b. a high r^2 and a high significance level for the F test.
    c. a high r^2 and a low significance level for the F test.
    d. a low r^2 and a high significance level for the F test.

Discussion Questions and Problems

Discussion Questions

4-1 What is the meaning of least squares in a regression model?

4-2 Discuss the use of dummy variables in regression analysis.

4-3 Discuss how the coefficient of determination and the coefficient of correlation are related and how they are used in regression analysis.

4-4 Explain how a scatter diagram can be used to identify the type of regression to use.

4-5 Explain how the adjusted r^2 value is used in developing a regression model.

4-6 Explain what information is provided by the F test.

4-7 What is the SSE? How is this related to the SST and the SSR?

4-8 Explain how a plot of the residuals can be used in developing a regression model.

ch5

Solved Problem 5-2

Quarterly demand for Jaguar XJ8's at a New York auto dealership is forecast with the equation

$$\hat{Y} = 10 + 3X$$

where

X = time period (quarter): quarter 1 of last year = 0
quarter 2 of last year = 1
quarter 3 of last year = 2
quarter 4 of last year = 3
quarter 1 of this year = 4, and so on

and

$\hat{Y}$ = predicted quarterly demand

The demand for luxury sedans is seasonal, and the indices for quarters 1, 2, 3, and 4 are 0.80, 1.00, 1.30, and 0.90, respectively. Using the trend equation, forecast the demand for each quarter of next year. Then adjust each forecast to adjust for seasonal (quarterly) variations.

Solution

Quarter 2 of this year is coded $X = 5$; quarter 3 of this year, $X = 6$; and quarter 4 of this year, $X = 7$. Hence, quarter 1 of next year is coded $X = 8$; quarter 2, $X = 9$; and so on.

$\hat{Y}$ (next year quarter 1) = 10 + (3)(8) = 34 Adjusted forecast = (0.80)(34) = 27.2
$\hat{Y}$ (next year quarter 2) = 10 + (3)(9) = 37 Adjusted forecast = (1.00)(37) = 37
$\hat{Y}$ (next year quarter 3) = 10 + (3)(10) = 40 Adjusted forecast = (1.30)(40) = 52
$\hat{Y}$ (next year quarter 4) = 10 + (3)(11) = 43 Adjusted forecast = (0.90)(43) = 38.7

Self-Test

- Before taking the self-test, refer to the learning objectives at the beginning of the chapter, the notes in the margins, and the glossary at the end of the chapter.
- Use the key at the back of the book to correct your answers.
- Restudy pages that correspond to any questions that you answered incorrectly or material you feel uncertain about.

1. Qualitative forecasting models include
   a. regression analysis.
   b. Delphi.
   c. time-series models.
   d. trend lines.
2. A forecasting model that only uses historical data for the variable being forecast is called a
   a. time-series model.
   b. causal model.
   c. Delphi model.
   d. variable model.
3. One example of a causal model is
   a. exponential smoothing.
   b. trend projections.
   c. moving averages.
   d. regression analysis.
4. Which of the following is a time series model?
   a. the Delphi model
   b. regression analysis
   c. exponential smoothing
   d. multiple regression
5. Which of the following is not a component of a time series?
   a. seasonality
   b. causal variations
   c. trend
   d. random variations
6. Which of the following may be negative?
   a. MAD
   b. bias
   c. MAPE
   d. MSE

7. When comparing several forecasting models to determine which one best fits a particular set of data, the model that should be selected is the one
   a. with the highest MSE.
   b. with the MAD closest to 1.
   c. with a bias of 0.
   d. with the lowest MAD.
8. In exponential smoothing, if you wish to give a significant weight to the most recent observations, then the smoothing constant should be
   a. close to 0.
   b. close to 1.
   c. close to 0.5.
   d. less than the error.
9. A trend equation is a regression equation in which
   a. there are multiple independent variables.
   b. the intercept and the slope are the same.
   c. the dependent variable is time.
   d. the independent variable is time.
10. Sales for a company are typically higher in the summer months than in the winter months. This variation would be called a
   a. trend.
   b. seasonal factor.
   c. random factor.
   d. cyclical factor.
11. A naïve forecast for monthly sales is equivalent to
   a. a one-month moving average model.
   b. an exponential smoothing model with $\alpha = 0$.
   c. a seasonal model in which the seasonal index is 1.
   d. none of the above.
12. If the seasonal index for January is 0.80, then
   a. January sales tend to be 80% higher than an average month.
   b. January sales tend to be 20% higher than an average month.
   c. January sales tend to be 80% lower than an average month.
   d. January sales tend to be 20% lower than an average month.
13. If both trend and seasonal components are present in a time-series, then the seasonal indices
   a. should be computed based on an overall average.
   b. should be computed based on CMAs.
   c. will all be greater than 1.
   d. should be ignored in developing the forecast.
14. Which of the following is used to alert the user of a forecasting model that a significant error occurred in one of the periods?
   a. a seasonal index
   b. a smoothing constant
   c. a tracking signal
   d. a regression coefficient
15. If the multiplicative decomposition model is used to forecast daily sales for a retail store, how many seasons will there be?
   a. 4
   b. 7
   c. 12
   d. 365

Discussion Questions and Problems

Discussion Questions

5-1 Describe briefly the steps used to develop a forecasting system.

5-2 What is a time-series forecasting model?

5-3 What is the difference between a causal model and a time-series model?

5-4 What is a qualitative forecasting model, and when is it appropriate?

5-5 What are some of the problems and drawbacks of the moving average forecasting model?

5-6 What effect does the value of the smoothing constant have on the weight given to the past forecast and the past observed value?

5-7 Describe briefly the Delphi technique.

5-8 What is MAD, and why is it important in the selection and use of forecasting models?

5-9 Explain how the number of season is determined when forecasting with a seasonal component.

5-10 A seasonal index may be less than one, equal to one, or greater than one. Explain what each of these values would mean.

5-11 Explain what would happen if the smoothing constant in an exponential smoothing model was equal to zero. Explain what would happen if the smoothing constant was equal to one.

5-12 Explain when a CMA (rather than an overall average) should be used in computing a seasonal index. Explain why this is necessary.

Problems

5-13 Develop a four-month moving average forecast for Wallace Garden Supply and compute the MAD.

Note: Q means the problem may be solved with QM for Windows; X means the problem may be solved with Excel QM; and Q X means the problem may be solved with QM for Windows and/or Excel QM.

ch6

Solution
Using the table for the normal distribution, the Z value for a 96% service level is about 1.75. The standard deviation is 200. The safety stock is calculated as

$$\text{SS} = z\sigma = 1.75(200) = 375 \text{ units}$$

For a normal distribution with a mean of 1,000, the reorder point is

$$\begin{aligned}\text{ROP} &= (\text{Average demand during lead time}) + \text{SS} \\ &= 1000 + 350 = 1{,}350 \text{ units}\end{aligned}$$

The total annual holding cost is

$$THC = \frac{Q}{2}C_h + (SS)C_h = \frac{5000}{2}4 + (350)4 = \$11{,}400$$

Self-Test

- Before taking the self-test, refer to the learning objectives at the beginning of the chapter, the notes in the margins, and the glossary at the end of the chapter.
- Use the key at the back of the book to correct your answers.
- Restudy pages that correspond to any questions that you answered incorrectly or material you feel uncertain about.

1. Which of the following is a basic component of an inventory control system?
   a. planning what inventory to stock and how to acquire it
   b. forecasting the demand for parts and products
   c. controlling inventory levels
   d. developing and implementing feedback measurements for revising plans and forecasts
   e. all of the above are components of an inventory control system
2. Which of the following is a valid use of inventory?
   a. the decoupling function
   b. to take advantage of quantity discounts
   c. to avoid shortages and stockouts
   d. to smooth out irregular supply and demand
   e. all of the above are valid uses of inventory
3. One assumption necessary for the EOQ model is instantaneous replenishment. This means
   a. the lead time is zero.
   b. the production time is assumed to be zero.
   c. the entire order is delivered at one time.
   d. replenishment cannot occur until the on-hand inventory is zero.
4. If the EOQ assumptions are met and a company orders the EOQ each time an order is placed, then the
   a. total annual holding costs are minimized.
   b. total annual ordering costs are minimized.
   c. total of all inventory costs are minimized.
   d. order quantity will always be less than the average inventory.
5. If the EOQ assumptions are met and a company orders more than the economic order quantity, then
   a. total annual holding cost will be greater than the total annual ordering cost.
   b. total annual holding cost will be less than the total annual ordering cost.
   c. total annual holding cost will be equal to the total annual ordering cost.
   d. total annual holding cost will be equal to the total annual purchase cost.
6. The reorder point is
   a. the quantity that is reordered each time an order is placed.
   b. the amount of inventory that would be needed to meet demand during the lead time.
   c. equal to the average inventory when the EOQ assumptions are met.
   d. assumed to be zero if there is instantaneous replenishment.
7. If the EOQ assumptions are met, then
   a. annual stockout cost will be zero.
   b. total annual holding cost will equal total annual ordering cost.
   c. average inventory will be one-half the order quantity.
   d. all of the above are true.
8. In the production run model, the maximum inventory level will be
   a. greater than the production quantity.
   b. equal to the production quantity.

c. less than the production quantity.
d. equal to the daily production rate plus the daily demand.

9. Why is the annual purchase (material) cost not considered to be a relevant inventory cost if the EOQ assumptions are met?
a. This cost will be zero.
b. This cost is constant and not affected by the order quantity.
c. This cost is insignificant compared with the other inventory costs.
d. This cost is never considered to be an inventory cost.

10. A JIT system will usually result in
a. a low annual holding cost.
b. very few orders per year.
c. frequent shutdowns in an assembly line.
d. high levels of safety stock.

11. Manufacturers use MRP when
a. the demand for one product is dependent on the demand for other products.
b. the demand for each product is independent of the demand for other products.
c. demand is totally unpredictable.
d. purchase cost is extremely high.

12. In using marginal analysis, an additional unit should be stocked if
a. MP = ML.
b. the probability of selling that unit is greater than or equal to MP/(MP + ML).
c. the probability of selling that unit is less than or equal to ML/(MP + ML).
d. the probability of selling that unit is greater than or equal to ML/(MP + ML).

13. In using marginal analysis with the normal distribution, if marginal profit is less than marginal loss, we expect the optimal stocking quantity to be
a. greater than the standard deviation.
b. less than the standard deviation.
c. greater than the mean.
d. less than the mean.

14. The inventory position is defined as
a. the amount of inventory needed to meet the demand during the lead time.
b. the amount of inventory on hand.
c. the amount of inventory on order.
d. the total of the on-hand inventory plus the on-order inventory.

Discussion Questions and Problems

Discussion Questions

6-1 Why is inventory an important consideration for managers?

6-2 What is the purpose of inventory control?

6-3 Under what circumstances can inventory be used as a hedge against inflation?

6-4 Why wouldn't a company always store large quantities of inventory to eliminate shortages and stockouts?

6-5 What are some of the assumptions made in using the EOQ?

6-6 Discuss the major inventory costs that are used in determining the EOQ.

6-7 What is the ROP? How is it determined?

6-8 What is the purpose of sensitivity analysis?

6-9 What assumptions are made in the production run model?

6-10 What happens to the production run model when the daily production rate becomes very large?

6-11 Briefly describe what is involved in solving a quantity discount model.

6-12 When using safety stock, how is the standard deviation of demand during the lead time calculated if daily demand is normally distributed but lead time is constant? How is it calculated if daily demand is constant but lead time is normally distributed? How is it calculated if both daily demand and lead time are normally distributed?

6-13 Briefly explain the marginal analaysis approach to the single period inventory problem.

6-14 Briefly describe what is meant by ABC analysis. What is the purpose of this inventory technique?

6-15 What is the overall purpose of MRP?

6-16 What is the difference between the gross and net material requirements plan?

6-17 What is the objective of JIT?

Problems

• 6-18 Lila Battle has determined that the annual demand for number 6 screws is 100,000 screws. Lila, who works in her brother's hardware store, is in charge of purchasing. She estimates that it costs $10 every time an order is placed. This cost includes her wages, the cost of the forms used in placing the order, and so on. Furthermore, she estimates that the cost of carrying one screw in inventory for a year is

Note: Q means the problem may be solved with QM for Windows; X means the problem may be solved with Excel QM; and QX means the problem may be solved with QM for Windows and/or Excel QM.

ch7

Self-Test

- Before taking the self-test, refer to the learning objectives at the beginning of the chapter, the notes in the margins, and the glossary at the end of the chapter.
- Use the key at the back of the book to correct your answers.
- Restudy pages that correspond to any questions that you answered incorrectly or material you feel uncertain about.

1. When using a graphical solution procedure, the region bounded by the set of constraints is called the
   a. solution.
   b. feasible region.
   c. infeasible region.
   d. maximum profit region.
   e. none of the above.
2. In an LP problem, at least one corner point must be an optimal solution if an optimal solution exists.
   a. True
   b. False
3. An LP problem has a bounded feasible region. If this problem has an equality (=) constraint, then
   a. this must be a minimization problem.
   b. the feasible region must consist of a line segment.
   c. the problem must be degenerate.
   d. the problem must have more than one optimal solution.
4. Which of the following would cause a change in the feasible region?
   a. increasing an objective function coefficient in a maximization problem
   b. adding a redundant constraint
   c. changing the right-hand side of a nonredundant constraint
   d. increasing an objective function coefficient in a minimization problem
5. If a nonredundant constraint is removed from an LP problem, then
   a. the feasible region will get larger.
   b. the feasible region will get smaller.
   c. the problem would become nonlinear.
   d. the problem would become infeasible.
6. In the optimal solution to a linear program, there are 20 units of slack for a constraint. From this we know that
   a. the dual price for this constraint is 20.
   b. the dual price for this constraint is 0.
   c. this constraint must be redundant.
   d. the problem must be a maximization problem.
7. A linear program has been solved and sensitivity analysis has been performed. The ranges for the objective function coefficients have been found. For the profit on X_1, the upper bound is 80, the lower bound is 60, and the current value is 75. Which of the following must be true if the profit on this variable is lowered to 70 and the optimal solution is found?
   a. a new corner point will become optimal
   b. the maximum possible total profit may increase
   c. the values for all the decision variables will remain the same
   d. all of the above are possible
8. A graphical method should only be used to solve an LP problem when
   a. there are only two constraints.
   b. there are more than two constraints.
   c. there are only two variables.
   d. there are more than two variables.
9. In LP, variables do not have to be integer valued and may take on any fractional value. This assumption is called
   a. proportionality.
   b. divisibility.
   c. additivity.
   d. certainty.
10. In solving a linear program, no feasible solution exists. To resolve this problem we might
    a. add another variable.
    b. add another constraint.
    c. remove or relax a constraint.
    d. try a different computer program.
11. If the feasible region gets larger due to a change in one of the constraints, the optimal value of the objective function
    a. must increase or remain the same for a maximization problem.
    b. must decrease or remain the same for a maximization problem.
    c. must increase or remain the same for a minimization problem.
    d. cannot change.
12. When alternate optimal solutions exist in an LP problem, then
    a. the objective function will be parallel to one of the constraints.
    b. one of the constraints will be redundant.
    c. two constraints will be parallel.
    d. the problem will also be unbounded.
13. If a linear program is unbounded, the problem probably has not been formulated correctly. Which of the following would most likely cause this?
    a. a constraint was inadvertently omitted
    b. an unnecessary constraint was added to the problem
    c. the objective function coefficients are too large
    d. the objective function coefficients are too small
14. A feasible solution to an LP problem
    a. must satisfy all of the problem's constraints simultaneously.
    b. need not satisfy all of the constraints, only some of them.
    c. must be a corner point of the feasible region.
    d. must give the maximum possible profit.

ch8

PROGRAM 8.10
Top Speed Bicycle Company Solution in Excel 2010

	A	B	C	D	E	F	G	H	I	J
1	Top Speed Bicycle Company									
2		N.O. to	N.O. to	N.O. to	Omaha to	Omaha to	Omaha to			
3		NY	Chicago	LA	NY	Chicago	LA			
4	Variables	X11	X12	X13	X21	X22	X23			
5	Values	10000	0	8000	0	8000	7000	Total Cost		
6	Cost	2	3	5	3	1	4	96000		
7										
8	Constraints							LHS	Sign	RHS
9	NY Demand	1			1			10000	=	10000
10	Chi. Demand		1			1		8000	=	8000
11	LA Demand			1			1	15000	=	15000
12	N.O. Supply	1	1	1				18000	≤	20000
13	Omaha Supply				1	1	1	15000	≤	15000

Solver Parameter Inputs and Selections

Set Objective: H6
By Changing cells: B5:G5
To: Min
Subject to the Constraints:
H9:H11 = J9:J11
H12:H13 <= J12:J13
Solving Method: Simplex LP
☑ **Make Variables Non-Negative**

Key Formulas

	H
5	Total Cost
6	=SUMPRODUCT($B$5:$G$5,B6:G6)

Copy H6 to H9:H13

Summary

In this chapter we continued our discussion of linear programming models. The basic steps for formulating a linear program were followed for a variety of problems. These included applications in marketing, production scheduling, finance, ingredient blending, and transportation. Attention was paid to understanding the problem, identifying the objective and the constraints, defining the decision variables, and developing the mathematical model from these.

In future chapters, additional applications of linear programming will be presented. The transportation problem seen in this chapter will be further discussed in Chapter 9, along with two other closely related applications: the assignment problem and the transshipment problem.

Self-Test

- Before taking the self-test, refer to the learning objectives at the beginning of the chapter, the notes in the margins, and the glossary at the end of the chapter.
- Use the key at the back of the book to correct your answers.
- Restudy pages that correspond to any questions that you answered incorrectly or material you feel uncertain about.

1. Linear programming can be used to select effective media mixes, allocate fixed or limited budgets across media, and maximize audience exposure.
   a. True
   b. False
2. Using LP to maximize audience exposure in an advertising campaign is an example of the type of LP application known as
   a. marketing research.
   b. media selection.
   c. portfolio assessment.
   d. media budgeting.
   e. all of the above.
3. Which of the following *does not* represent a factor manager might consider when employing LP for production scheduling:
   a. labor capacity
   b. space limitations
   c. product demand
   d. risk assessment
   e. inventory costs

4. A typical transportation problem has 4 sources and 3 destinations. How many decision variables would there be in the linear program for this?
   a. 3
   b. 4
   c. 7
   d. 12
5. A typical transportation problem has 4 sources and 3 destinations. How many constraints would there be in the linear program for this?
   a. 3
   b. 4
   c. 7
   d. 12
6. When applying LP to diet problems, the objective function is usually designed to
   a. maximize profits from blends of nutrients.
   b. maximize ingredient blends.
   c. minimize production losses.
   d. maximize the number of products to be produced.
   e. minimize the costs of nutrient blends.
7. The diet problem is
   a. also called the feed mix problem in agriculture.
   b. a special case of the ingredient mix problem.
   c. a special case of the blending problem.
   d. all of the above.
8. The selection of specific investments from among a wide variety of alternatives is the type of LP problem known as
   a. the product mix problem.
   b. the investment banker problem.
   c. the portfolio selection problem.
   d. the Wall Street problem.
   e. none of the above.

Problems

8-1 ***(Production problem)*** Winkler Furniture manufactures two different types of china cabinets: a French Provincial model and a Danish Modern model. Each cabinet produced must go through three departments: carpentry, painting, and finishing. The table below contains all relevant information concerning production times per cabinet produced and production capacities for each operation per day, along with net revenue per unit produced. The firm has a contract with an Indiana distributor to produce a minimum of 300 of each cabinet per week (or 60 cabinets per day). Owner Bob Winkler would like to determine a product mix to maximize his daily revenue.

(a) Formulate as an LP problem.
(b) Solve using an LP software program or spreadsheet.

8-2 ***(Investment decision problem)*** The Heinlein and Krampf Brokerage firm has just been instructed by one of its clients to invest $250,000 of her money obtained recently through the sale of land holdings in Ohio. The client has a good deal of trust in the investment house, but she also has her own ideas about the distribution of the funds being invested. In particular, she requests that the firm select whatever stocks and bonds they believe are well rated, but within the following guidelines:

(a) Municipal bonds should constitute at least 20% of the investment.
(b) At least 40% of the funds should be placed in a combination of electronic firms, aerospace firms, and drug manufacturers.
(c) No more than 50% of the amount invested in municipal bonds should be placed in a high-risk, high-yield nursing home stock.

Subject to these restraints, the client's goal is to maximize projected return on investments. The analysts at Heinlein and Krampf, aware of these guidelines,

Data for Problem 8-1

CABINET STYLE	CARPENTRY (HOURS/ CABINET)	PAINTING (HOURS/ CABINET)	FINISHING (HOURS/ CABINET)	NET REVENUE/ CABINET ($)
French Provincial	3	1.5	0.75	28
Danish Modern	2	1	0.75	25
Department capacity (hours)	360	200	125	

Note: Q means the problem may be solved with QM for Windows; X means the problem may be solved with Excel; and Q X means the problem may be solved with QM for Windows and/or Excel.

ch9

e. Subtract smallest uncovered number (100), add it to squares where two lines intersect, and cover all zeros.

HIREE \ OFFICE	OMAHA	MIAMI	DALLAS	NEW YORK
JONES	~~100~~	~~0~~	~~100~~	~~0~~
SMITH	~~0~~	~~700~~	~~400~~	~~0~~
WILSON	~~0~~	~~100~~	~~1,400~~	~~700~~
DUMMY	~~400~~	~~0~~	~~0~~	~~100~~

f. Since it takes four lines to cover all zeros, an optimal assignment can be made at zero squares. We assign

Dummy (no one) to Dallas
Wilson to Omaha
Smith to New York
Jones to Miami
Cost = \$0 + \$500 + \$800 + \$1,100 = \$2,400

Self-Test

- Before taking the self-test, refer to the learning objectives at the beginning of the chapter, the notes in the margins, and the glossary at the end of the chapter.
- Use the key at the back of the book to correct your answers.
- Restudy pages that correspond to any questions that you answered incorrectly or material you feel uncertain about.

1. If the total demand equals the total supply in a transportation problem, the problem is
   a. degenerate.
   b. balanced.
   c. unbalanced.
   d. infeasible.
2. If a transportation problem has 4 sources and 5 destinations, the linear program for this will have
   a. 4 variables and 5 constraints.
   b. 5 variable and 4 constraints.
   c. 9 variables and 20 constraints.
   d. 20 variables and 9 constraints.
3. In a transportation problem, what indicates that the minimum cost solution has been found?
   a. all improvement indices are negative or zero
   b. all improvement indices are positive or zero
   c. all improvement indices are equal to zero
   d. all cells in the dummy row are empty
4. An assignment problem may be viewed as a transportation problem with
   a. a cost of \$1 for all shipping routes.
   b. all supplies and demands equal to 1.
   c. only demand constraints.
   d. only supply constraints.
5. If the number of filled cells in a transportation table does not equal the number of rows plus the number of columns minus 1, then the problem is said to be
   a. unbalanced.
   b. degenerate.
   c. optimal.
   d. maximization problem.
6. If a solution to a transportation problem is degenerate, then
   a. it will be impossible to evaluate all empty cells without removing the degeneracy.
   b. a dummy row or column must be added.
   c. there will be more than one optimal solution.
   d. the problem has no feasible solution.
7. If the total demand is greater than the total capacity in a transportation problem, then
   a. the optimal solution will be degenerate.
   b. a dummy source must be added.
   c. a dummy destination must be added.
   d. both a dummy source and a dummy destination must be added.

8. In solving a facility location problem in which there are two possible locations being considered, the transportation algorithm may be used. In doing this,
   a. two rows (sources) would be added to the existing rows and the enlarged problem would be solved.
   b. two separate transportation problems would be solved.
   c. costs of zero would be used for each of the new facilities.
   d. the problem would be a transshipment problem.
9. The Hungarian method is
   a. a way to develop an initial solution to a transportation problem.
   b. used to solve assignment problems.
   c. also called Vogel's approximation method.
   d. only used for problems in which the objective is to maximize profit.
10. In an assignment problem, it may be necessary to add more than one row to the table.
    a. True
    b. False
11. When using the Hungarian method, an optimal assignment can always be made when every row and every column has at least one zero.
    a. True
    b. False
12. An assignment problem can be viewed as a special type of transportation problem with which of the following features?
    a. the capacity for each source and the demand for each destination is equal to one
    b. the number of rows is equal to the number of columns
    c. the cost for each shipping route is equal to one
    d. all of the above

Discussion Questions and Problems

Discussion Questions

9-1 Is the transportation model an example of decision making under certainty or decision making under uncertainty? Why?

9-2 Explain how to determine the number of variables and constraints that would be in a transportation problem simply by knowing the number of sources and the number of destinations.

9-3 What is a *balanced* transportation problem? Describe the approach you would use to solve an *unbalanced* problem.

9-4 The stepping-stone method is being used to solve a transportation problem. The smallest quantity in a cell with a minus sign is 35, but two different cells with minus signs have 35 units in them. What problem will this cause, and how should this difficulty be resolved?

9-5 The stepping-stone method is being used to solve a transportation problem. There is only one empty cell having a negative improvement index, and this index is -2. The stepping-stone path for this cell indicates that the smallest quantity for the cells with minus signs is 80 units. If the total cost for the current solution is \$900, what will the total cost be for the improved solution? What can you conclude about how much the total cost will decrease when developing each new solution for any transportation problem?

9-6 Explain what happens when the solution to a transportation problem does not have $m + n - 1$ occupied squares (where m = number of rows in the table and n = number of columns in the table).

9-7 What is the enumeration approach to solving assignment problems? Is it a practical way to solve a 5 row $\times$ 5 column problem? a 7 $\times$ 7 problem? Why?

9-8 How could an assignment problem be solved using the transportation approach? What condition will make the solution of this problem difficult?

9-9 You are the plant supervisor and are responsible for scheduling workers to jobs on hand. After estimating the cost of assigning each of five available workers in your plant to five projects that must be completed immediately, you solve the problem using the Hungarian method. The following solution is reached and you post these job assignments:

Jones to project *A*

Smith to project *B*

Thomas to project *C*

Gibbs to project *D*

Heldman to project *E*

The optimal cost was found to be \$492 for these assignments. The plant general manager inspects your original cost estimates and informs you that increased employee benefits mean that each of the 25 numbers in your cost table is too low by \$5. He suggests that you immediately rework the problem and post the new assignments.

Is this necessary? Why? What will the new optimal cost be?

9-10 Sue Simmons's marketing research firm has local representatives in all but five states. She decides to expand to cover the whole United States by transferring five experienced volunteers from their current locations to new offices in each of the five states. Simmons's goal is to relocate the five representatives at the least total cost. Consequently, she sets up a 5 $\times$ 5 relocation cost table and prepares to solve it for the best assignments by use of the Hungarian

ch12

Solved Problem 12-2

Referring to Solved Problem 12-1, now Scott would like to determine the critical path for the entire wing assembly project as well as the expected completion time for the total project. In addition, he would like to determine the earliest and latest start and finish times for all activities.

Solution

The critical path, earliest start times, earliest finish times, latest start times, and latest finish times can be determined using the procedures outlined in the chapter. The results are summarized in the following table:

	ACTIVITY TIME				
ACTIVITY	ES	EF	LS	LF	SLACK
A	0	2	5	7	5
B	0	3	0	3	0
C	2	7	7	12	5
D	3	12	3	12	0
E	12	17	12	17	0
F	3	8	14	19	11
G	17	19	17	19	0

Expected project length = 19 weeks
Variance of the critical path = 1.333
Standard deviation of the critical path = 1.155 weeks

The activities along the critical path are *B, D, E,* and *G*. These activities have zero slack, as shown in the table. The expected project completion time is 19. The earliest and latest start and finish times are shown in the table.

Self-Test

- Before taking the self-test, refer to the learning objectives at the beginning of the chapter, the notes in the margins, and the glossary at the end of the chapter.
- Use the key at the back of the book to correct your answers.
- Restudy pages that correspond to any questions that you answered incorrectly or material you feel uncertain about.

1. Network models such as PERT and CPM are used
   a. to plan large and complex projects.
   b. to schedule large and complex projects.
   c. to monitor large and complex projects.
   d. to control large and complex projects.
   e. for all of the above.
2. The primary difference between PERT and CPM is that
   a. PERT uses one time estimate.
   b. CPM has three time estimates.
   c. PERT has three time estimates.
   d. with CPM, it is assumed that all activities can be performed at the same time.
3. The earliest start time for an activity is equal to
   a. the largest EF of the immediate predecessors.
   b. the smallest EF of the immediate predecessors.
   c. the largest ES of the immediate predecessors.
   d. the smallest ES of the immediate predecessors.
4. The latest finish time for an activity is found during the backward pass through the network. The latest finish time is equal to
   a. the largest LF of the activities for which it is an immediate predecessor.
   b. the smallest LF of the activities for which it is an immediate predecessor.
   c. the largest LS of the activities for which it is an immediate predecessor.
   d. the smallest LS of the activities for which it is an immediate predecessor.
5. When PERT is used and probabilities are found, one of the assumptions that is made is that
   a. all activities are on the critical path.
   b. activity times are independent.
   c. all activities have the same variance.
   d. the project variance is equal to the sum of the variances of all activities in the project.
   e. all of the above.

6. In PERT, the time estimate *b* represents
   a. the most optimistic time.
   b. the most likely time.
   c. the most pessimistic time.
   d. the expected time.
   e. none of the above.
7. In PERT, slack time equals
   a. ES + *t*.
   b. LS − ES.
   c. 0.
   d. EF − ES.
   e. none of the above.
8. The standard deviation for the PERT project is approximately
   a. the square root of the sum of the variances along the critical path.
   b. the sum of the critical path activity standard deviations.
   c. the square root of the sum of the variances of the project activities.
   d. all of the above.
   e. none of the above.
9. The critical path is the
   a. shortest path in a network.
   b. longest path in a network.
   c. path with the smallest variance.
   d. path with the largest variance.
   e. none of the above.
10. If the project completion time is normally distributed and the due date for the project is greater than the expected completion time, then the probability that the project will be finished by the due date is
    a. less than 0.50.
    b. greater than 0.50.
    c. equal to 0.50.
    d. undeterminable without more information.
11. If activity *A* is not on the critical path, then the slack for *A* will equal
    a. LF − EF.
    b. EF − ES.
    c. 0.
    d. all of the above.
12. If a project is to be crashed at the minimum possible additional cost, then the first activity to be crashed must be
    a. on the critical path.
    b. the one with the shortest activity time.
    c. the one with the longest activity time.
    d. the one with the lowest cost.
13. _____ activities are ones that will delay the entire project if they are late or delayed.
14. PERT stands for _____.
15. Project crashing can be performed using a _____.
16. PERT can use three estimates for activity time. These three estimates are _____, _____, and _____.
17. The latest start time minus the earliest start time is called the _____ time for any activity.
18. The percent of project completion, value of work completed, and actual activity costs are used to _____ projects.

Discussion Questions and Problems

Discussion Questions

12-1 What are some of the questions that can be answered with PERT and CPM?

12-2 What are the major differences between PERT and CPM?

12-3 What is an activity? What is an event? What is an immediate predecessor?

12-4 Describe how expected activity times and variances can be computed in a PERT network.

12-5 Briefly discuss what is meant by critical path analysis. What are critical path activities, and why are they important?

12-6 What are the earliest activity start time and latest activity start time? How are they computed?

12-7 Describe the meaning of slack and discuss how it can be determined.

12-8 How can we determine the probability that a project will be completed by a certain date? What assumptions are made in this computation?

12-9 Briefly describe PERT/Cost and how it is used.

12-10 What is crashing, and how is it done by hand?

12-11 Why is linear programming useful in CPM crashing?

Problems*

12-12 Sid Davidson is the personnel director of Babson and Willcount, a company that specializes in consulting and research. One of the training programs that Sid is considering for the middle-level managers of Babson and Willcount is leadership training. Sid has listed a number of activities that must be completed before a training program of this nature

*Note: Q means the problem may be solved with QM for Windows; X means the problem may be solved with Excel QM; and Q X means the problem may be solved with QM for Windows and/or Excel.

ch13

$$L = \left[\frac{(20)(30)(20/30)^2}{(2-1)![(2)(30-20)]^2}\right]0.5 + \frac{20}{30} = 0.75 \text{ customer in the system on the average}$$

$$W = \frac{L}{\lambda} = \frac{3/4}{20} = \frac{3}{80}\text{ hour} = 2.25 \text{ minutes that the average customer spends in the total system}$$

$$L_q = L - \frac{\lambda}{\mu} = \frac{3}{4} - \frac{20}{30} = \frac{1}{12} = 0.083 \text{ customer waiting for service in line on the average}$$

$$W_q = \frac{L_q}{\lambda} = \frac{1/2}{20} = \frac{1}{240}\text{ hour} = \frac{1}{4}\text{ minute} = \text{average waiting time of a customer in the queue itself (not being serviced)}$$

$$\rho = \frac{\lambda}{m\mu} = \frac{20}{2(30)} = \frac{1}{3} = 0.33 = \text{utilization rate}$$

You now have (240 customers) × (1/240 hour) = 1 hour total customer waiting time per day.

Total cost of 60 minutes of customer waiting time is (60 minutes)($0.10 per minute) = $6.

Now you are ready to point out to Marty that the hiring of one additional clerk will save $96 – $6 = $90 of customer ill will per 12-hour shift. Marty responds that the hiring should also reduce the number of people who look at the line and leave as well as those who get tired of waiting in line and leave. You tell Marty that you are ready for two chili dogs, extra hot.

Solved Problem 13-4

Vacation Inns is a chain of hotels operating in the southwestern part of the United States. The company uses a toll-free telephone number to take reservations for any of its hotels. The average time to handle each call is 3 minutes, and an average of 12 calls are received per hour. The probability distribution that describes the arrivals is unknown. Over a period of time it is determined that the average caller spends 6 minutes either on hold or receiving service. Find the average time in the queue, the average time in the system, the average number in the queue, and the average number in the system.

Solution

The probability distributions are unknown, but we are given the average time in the system (6 minutes). Thus, we can use Little's Flow Equations:

$$W = 6 \text{ minutes} = 6/60 \text{ hour} = 0.1 \text{ hour}$$
$$\lambda = 12 \text{ per hour}$$
$$\mu = 60/3 = 20 \text{ per hour}$$
$$\text{Average time in queue} = W_q = W - 1/\mu = 0.1 - 1/20 = 0.1 - 0.05 = 0.05 \text{ hour}$$
$$\text{Average number in system} = L = \lambda W = 12(0.1) = 1.2 \text{ callers}$$
$$\text{Average number in queue} = L_q = \lambda W_q = 12(0.05) = 0.6 \text{ caller}$$

Self-Test

- Before taking the self-test, refer to the learning objectives at the beginning of the chapter, the notes in the margins, and the glossary at the end of the chapter.
- Use the key at the back of the book to correct your answers.
- Restudy pages that correspond to any questions that you answered incorrectly or material you feel uncertain about.

1. Most systems use the queue discipline known as the FIFO rule.
   a. True
   b. False

2. Before using exponential distributions to build queuing models, the quantitative analyst should determine if the service time data fit the distribution.
   a. True
   b. False

3. In a multichannel, single-phase queuing system, the arrival will pass through at least two different service facilities.
   a. True
   b. False
4. Which of the following is *not* an assumption in $M/M/1$ models?
   a. arrivals come from an infinite or very large population
   b. arrivals are Poisson distributed
   c. arrivals are treated on a FIFO basis and do not balk or renege
   d. service times follow the exponential distribution
   e. the average arrival rate is faster than the average service rate
5. A queuing system described as $M/D/2$ would have
   a. exponential service times.
   b. two queues.
   c. constant service times.
   d. constant arrival rates.
6. Cars enter the drive-through of a fast-food restaurant to place an order, and then they proceed to pay for the food and pick up the order. This is an example of
   a. a multichannel system.
   b. a multiphase system.
   c. a multiqueue system.
   d. none of the above.
7. The utilization factor for a system is defined as
   a. mean number of people served divided by the mean number of arrivals per time period.
   b. the average time a customer spends waiting in a queue.
   c. proportion of the time the service facilities are in use.
   d. the percentage of idle time.
   e. none of the above.
8. Which of the following would not have a FIFO queue discipline?
   a. fast-food restaurant
   b. post office
   c. checkout line at grocery store
   d. emergency room at a hospital
9. A company has one computer technician who is responsible for repairs on the company's 20 computers. As a computer breaks, the technician is called to make the repair. If the repairperson is busy, the machine must wait to be repaired. This is an example of
   a. a multichannel system.
   b. a finite population system.
   c. a constant service rate system.
   d. a multiphase system.
10. In performing a cost analysis of a queuing system, the waiting time cost (C_w) is sometimes based on the time in the queue and sometimes based on the time in the system. The waiting cost should be based on time in the system for which of the following situations?
    a. waiting in line to ride an amusement park ride
    b. waiting to discuss a medical problem with a doctor
    c. waiting for a picture and an autograph from a rock star
    d. waiting for a computer to be fixed so it can be placed back in service
11. Customers enter the waiting line at a cafeteria on a first-come, first-served basis. The arrival rate follows a Poisson distribution, and service times follow an exponential distribution. If the average number of arrivals is 6 per minute and the average service rate of a single server is 10 per minute, what is the average number of customers in the system?
    a. 0.6
    b. 0.9
    c. 1.5
    d. 0.25
    e. none of the above
12. In the standard queuing model, we assume that the queue discipline is _____.
13. The service *time* in the $M/M/1$ queuing model is assumed to be _____.
14. When managers find standard queuing formulas inadequate or the mathematics unsolvable, they often resort to _____ to obtain their solutions.

Discussion Questions and Problems

Discussion Questions

13-1 What is the waiting line problem? What are the components in a waiting line system?

13-2 What are the assumptions underlying common queuing models?

13-3 Describe the important operating characteristics of a queuing system.

13-4 Why must the service rate be greater than the arrival rate in a single-channel queuing system?

13-5 Briefly describe three situations in which the FIFO discipline rule is not applicable in queuing analysis.

13-6 Provide examples of four situations in which there is a limited, or finite, population.

13-7 What are the components of the following systems? Draw and explain the configuration of each.
(a) barbershop
(b) car wash
(c) laundromat
(d) small grocery store

13-8 Give an example of a situation in which the waiting time cost would be based on waiting time in the queue. Give an example of a situation in which the waiting time cost would be based on waiting time in the system.

13-9 Do you think the Poisson distribution, which assumes independent arrivals, is a good estimation of arrival

ch14

Self-Test

- Before taking the self-test, refer to the learning objectives at the beginning of the chapter, the notes in the margins, and the glossary at the end of the chapter.
- Use the key at the back of the book to correct your answers.
- Restudy pages that correspond to any questions that you answered incorrectly or material you feel uncertain about.

1. Simulation is a technique usually reserved for studying only the simplest and most straightforward of problems.
   a. True
   b. False
2. A simulation model is designed to arrive at a single specific numerical answer to a given problem.
   a. True
   b. False
3. Simulation typically requires a familiarity with statistics to evaluate the results.
   a. True
   b. False
4. The verification process involves making sure that
   a. the model adequately represents the real-world system.
   b. the model is internally consistent and logical.
   c. the correct random numbers are used.
   d. enough trial runs are simulated.
5. The validation process involves making sure that
   a. the model adequately represents the real-world system.
   b. the model is internally consistent and logical.
   c. the correct random numbers are used.
   d. enough trial runs are simulated.
6. Which of the following is an *advantage* of simulation?
   a. It allows time compression.
   b. It is always relatively simple and inexpensive.
   c. The results are usually transferable to other problems.
   d. It will always find the optimal solution to a problem.
7. Which of the following is a *disadvantage* of simulation?
   a. It is inexpensive even for the most complex problem.
   b. It always generates the optimal solution to a problem.
   c. The results are usually transferable to other problems.
   d. Managers must generate all of the conditions and constraints for solutions that they wish to examine.
8. A meteorologist was simulating the number of days that rain would occur in a month. The random number interval from 01 to 30 was used to indicate that rain occurred on a particular day, and the interval 31–00 indicated that rain did not occur. What is the probability that rain did occur?
   a. 0.30
   b. 0.31
   c. 1.00
   d. 0.70
9. Simulation is best thought of as a technique to
   a. give concrete numerical answers.
   b. increase understanding of a problem.
   c. provide rapid solutions to relatively simple problems.
   d. provide optimal solutions to complex problems.
10. When simulating the Monte Carlo experiment, the average simulated demand over the long run should approximate the
    a. real demand.
    b. expected demand.
    c. sample demand.
    d. daily demand.
11. The idea behind simulation is to
    a. imitate a real-world situation.
    b. study the properties and operating characteristics of a real-world situation.
    c. draw conclusions and make action decisions based on simulation results.
    d. all of the above.
12. Using simulation for a queuing problem would be appropriate if
    a. the arrival rate follows a Poisson distribution.
    b. the service rate is constant.
    c. the FIFO queue discipline is assumed.
    d. there is a 10% chance an arrival would leave before receiving service.
13. A probability distribution has been developed, and the probability of 2 arrivals in the next hour is 0.20. A random number interval is to be assigned to this. Which of the following would *not* be an appropriate interval?
    a. 01–20
    b. 21–40
    c. 00–20
    d. 00–19
    e. all of the above would be appropriate
14. In a Monte Carlo simulation, a variable that we might want to simulate is
    a. lead time for inventory orders to arrive.
    b. times between machine breakdowns.
    c. times between arrivals at a service facility.
    d. number of employees absent from work each day.
    e. all of the above.
15. Use the following random numbers to simulate *yes* and *no answers* to 10 questions by starting in the first *row* and letting
    a. the double-digit numbers 00–49 represent *yes*, and 50–99 represent *no*.
    b. the double-digit even numbers represent *yes*, and the odd numbers represent *no*.
    Random numbers: 52 06 50 88 53 30 10 47 99 37 66 91 35 32 00 84 57 00

Appendix H: Solutions to Self-Tests

Chapter 1

1. c
2. d
3. b
4. b
5. c
6. c
7. d
8. c
9. d
10. a
11. a
12. quantitative analysis
13. defining the problem
14. schematic model
15. algorithm

Chapter 2

1. c
2. b
3. a
4. d
5. b
6. c
7. a
8. c
9. b
10. d
11. b
12. a
13. a
14. b
15. a

Chapter 3

1. b
2. c
3. c
4. a
5. c
6. b
7. a
8. c
9. a
10. d
11. b
12. c
13. c
14. a
15. c
16. b

Chapter 4

1. b
2. c
3. d
4. b
5. b
6. c
7. b
8. c
9. a
10. b
11. b
12. c

Chapter 5

1. b
2. a
3. d
4. c
5. b
6. b
7. d
8. b
9. d
10. b
11. a
12. d
13. b
14. c
15. b

Chapter 6

1. e
2. e
3. c
4. c
5. a
6. b
7. d
8. c
9. b
10. a
11. a
12. d
13. d
14. d

Chapter 7

1. b
2. a
3. b
4. c
5. a
6. b
7. c
8. c
9. b
10. c
11. a
12. a
13. a
14. a

Chapter 8

1. a
2. b
3. d
4. d
5. c
6. e
7. d
8. c

Chapter 9

1. b
2. d
3. b
4. b
5. b
6. a
7. b
8. b
9. b
10. a
11. b
12. a

Chapter 10

1. a
2. b
3. a
4. a
5. a
6. b
7. b
8. b
9. d
10. b
11. e

Chapter 11

1. c
2. e
3. b
4. c
5. b
6. a
7. d
8. a
9. b
10. b
11. a
12. d
13. shortest route
14. maximal flow
15. minimal spanning tree

Chapter 12

1. e
2. c
3. a
4. d
5. b
6. c
7. b
8. a
9. b
10. b
11. a
12. a
13. Critical path (or critical)
14. program evaluation and review technique
15. linear programming model
16. optimistic, most likely, pessimistic
17. slack
18. monitor and control

Chapter 13

1. a
2. a
3. b
4. e
5. c
6. b
7. c
8. d
9. b
10. d
11. c
12. first-come, first-served
13. negative exponentially distributed
14. simulation

Chapter 14

1. b
2. b
3. a
4. b
5. a
6. a
7. d
8. a
9. b
10. b
11. d
12. d
13. c
14. e
15. (a) no, yes, no, no, no, yes, yes, yes, no, yes
    (b) yes, yes, yes, yes, no, yes, yes, no, no, no

Chapter 15

1. b
2. a
3. c
4. c
5. b
6. a
7. a
8. a
9. b
10. matrix of transition probabilities
11. collectively exhaustive, mutually exclusive
12. vector of state probabilities

Chapter 16

1. b
2. c
3. d
4. a
5. c
6. b
7. c
8. d
9. b
10. b

Module 1

1. a
2. d
3. b
4. b
5. c
6. b
7. b
8. b

Module 2

1. c
2. b
3. e
4. c
5. b
6. a
7. c
8. e
9. a
10. a
11. c
12. c
13. b
14. b

Module 3

1. c
2. d
3. b
4. a
5. b
6. b
7. c

Module 4

1. b
2. a
3. c
4. b
5. b
6. b
7. a

Module 5

1. c
2. a
3. b
4. c
5. b
6. a
7. e
8. d

Module 6

1. a
2. d
3. a
4. b
5. c
6. d
7. d

Module 7

1. a
2. d
3. d
4. a
5. a
6. d
7. a
8. d
9. b
10. a
11. a
12. b
13. c
14. c
15. d
16. a
17. b