Solution and Answer Guide

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# Problems

1. **Vocabulary.** Define the terms *management science* and *operations research*. **LO 1**

Solutions:

Management science and operations research, terms used almost interchangeably, are broad disciplines that employ scientific methodology in managerial decision making or problem solving. Drawing upon a variety of disciplines (behavioral, mathematical, etc.), management science and operations research combine quantitative and qualitative considerations in order to establish policies and decisions that are in the best interest of the organization.

2. **The Decision-Making Process.** List and discuss the steps of the decision-making process. **LO 2**

Solutions:

1. Define the problem.
2. Identify the alternatives.
3. Determine the criteria.
4. Evaluate the alternatives.
5. Choose an alternative.
6. For further discussion, see Section 1.3.

3. **Roles of Qualitative and Quantitative Approaches to Decision Making.** Discuss the different roles played by the qualitative and quantitative approaches to managerial decision making. Why is it important for a manager or decision maker to have a good understanding of both of these approaches to decision making? **LO 2**

Solutions:

See Section 1.2.

4. **Production Scheduling.** A firm just completed a new plant that will produce more than 500 different products, using more than 50 different production lines and machines. The production scheduling decisions are critical in that sales will be lost if customer demands are not met on time. If no individual in the firm has experience with this production operation and if new production schedules must be generated each week, why should the firm consider a quantitative approach to the production scheduling problem? **LO 2**

Solutions:

A quantitative approach should be considered because the problem is large, complex, important, new, and repetitive.

5. **Advantages of Modeling.** List the advantages of analyzing and experimenting with a model as opposed to a real object or situation. **LO 3**

Solutions:

Models usually have time, cost, and risk advantages over experimenting with actual situations.

6. **Choosing Between Models.** Suppose that a manager has a choice between the following two mathematical models of a given situation: (a) a relatively simple model that is a reasonable approximation of the real situation, and (b) a thorough and complex model that is the most accurate mathematical representation of the real situation possible. Why might the model described in part (a) be preferred by the manager? **LO 3**

Solutions:

Model (a) may be quicker to formulate, easier to solve, and/or more easy to understand.

7. **Modeling Fu**e**l Cost.** Suppose you are going on a weekend trip to a city that is *d* miles away. Develop a model that determines your round-trip gasoline costs. What assumptions or approximations are necessary to treat this model as a deterministic model? Are these assumptions or approximations acceptable to you? **LO 3**

Solutions:

Let *d* = distance

*m* = miles per gallon

*c* = cost per gallon,

∴ Total Cost =

We must be willing to treat *m* and *c* as known and not subject to variation.

8. **Adding a Second Product to a Production Model.** Recall the production model from   
Section 1.3:

Max 10*x*

s.t.

5*x* ≤ 40

*x* ≥ 0

Suppose the firm in this example considers a second product that has a unit profit of $5 and requires 2 hours of production time for each unit produced. Use *y* as the number of units of product 2 produced. **LO 4**

a. Show the mathematical model when both products are considered simultaneously.

b. Identify the controllable and uncontrollable inputs for this model.

c. Draw the flowchart of the input–output process for this model (see Figure 1.5).

d. What are the optimal solution values of *x* and *y*?

e. Is the model developed in part (a) a deterministic or a stochastic model? Explain.

Solutions:

a. Maximize 10*x* + 5*y*

s.t.

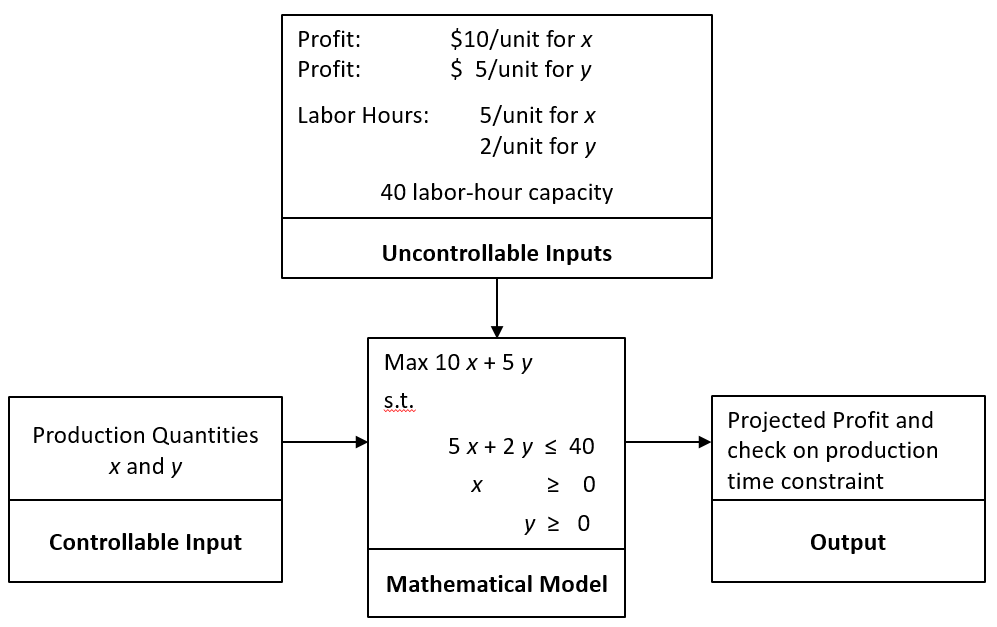
5*x* + 2*y* ≤ 40

*x* ≥ 0, *y* ≥ 0

b. Controllable inputs: *x* and *y*

Uncontrollable inputs: profit (10,5), labor hours (5,2), and labor-hour availability (40)

c.



d. *x* = 0, *y* = 20 Profit = $100

(Solution by trial-and-error)

e. Deterministic—all uncontrollable inputs are fixed and known.

9. **Stochastic Production Models.** Suppose we modify the production model in Section 1.3 to obtain the following mathematical model:

Max 10*x*

s.t.

*ax* ≤ 40

*x* ≥ 0

where *a* is the number of hours of production time required for each unit produced. With  
*a* = 5, the optimal solution is *x* = 8. If we have a stochastic model with *a* = 3, *a* = 4,  
*a* = 5, or *a* = 6 as the possible values for the number of hours required per unit, what is the optimal value for *x*? What problems does this stochastic model cause? **LO 4**

Solutions:

If *a* = 3, *x* = 13 1/3, and profit = 133.

If *a* = 4, *x* = 10, and profit = 100.

If *a* = 5, *x* = 8, and profit = 80.

If *a* = 6, *x* = 6 2/3, and profit = 67.

Since *a* is unknown, the actual values of *x* and profit are not known with certainty.

10. **Modeling Shipments.** A retail store in Des Moines, Iowa, receives shipments of a particular product from Kansas City and Minneapolis. Define *x* and *y* as follows. **LO 4**

*x* = number of units of the product received from Kansas City

*y* = number of units of the product received from Minneapolis

a. Write an expression for the total number of units of the product received by the retail store in Des Moines.

b. Shipments from Kansas City cost $0.20 per unit, and shipments from Minneapolis cost $0.25 per unit. Develop an objective function representing the total cost of shipments to Des Moines.

c. Assuming the monthly demand at the retail store is 5000 units, develop a constraint that requires 5000 units to be shipped to Des Moines.

d. No more than 4000 units can be shipped from Kansas City, and no more than 3000 units can be shipped from Minneapolis in a month. Develop constraints to model this situation.

e. Of course, negative amounts cannot be shipped. Combine the objective function and constraints developed to state a mathematical model for satisfying the demand at the Des Moines retail store at minimum cost.

Solutions:

a. Total Units Received = *y*

*x* +

b. Total Cost = 0.20*x* + 0.25*y*

c. *x* + *y* = 5000

d. *x* ≤ 4000 Kansas City Constraint

*y* ≤ 3000 Minneapolis Constraint

e. Min 0.20*x* + 0.25*y*

s.t.

*x* + *y* = 5000

*x* ≤ 4000

*y* ≤ 3000

*x*, *y* ≥ 0

11. **Modeling Demand as a Function of Price.** For most products, higher prices result in a decreased demand, whereas lower prices result in an increased demand. Let

*d* = annual demand for a product in units

*p* = price per unit

Assume that a firm accepts the following price–demand relationship as being realistic:

*d* = 800 – 10*p*

where *p* must be between $20 and $70. **LO 4**

a. How many units can the firm sell at the $20 per-unit price? At the $70 per-unit price?

b. What happens to annual units demanded for the product if the firm increases the per-unit price from $26 to $27? From $42 to $43? From $68 to $69? What is the suggested relationship between the per-unit price and annual demand for the product in units?

c. Show the mathematical model for the total revenue (TR), which is the annual demand multiplied by the unit price.

d. Based on other considerations, the firm’s management will only consider price alternatives of $30, $40, and $50. Use your model from part (b) to determine the price alternative that will maximize the total revenue.

e. What are the expected annual demand and the total revenue corresponding to your recommended price?

Solutions:

a. At $20 *d* = 800 − 10(20) = 600

At $70 *d* = 800 − 10(70) = 100

b. At $26 *d* = 800 − 10(26) = 540

At $27 *d* = 800 − 10(27) = 530

If the firm increases the per unit price from $26 to $27, the number of units the firm can sell falls by 10.

At $42 *d* = 800 − 10(42) = 380

At $43 *d* = 800 − 10(43) = 370

If the firm increases the per unit price from $426 to $43, the number of units the firm can sell falls by 10.

This suggests that the relationship between the per-unit price and annual demand for the product in units is linear between $20 and $70 and that annual demand for the product decreases by 10 units when the price is increased by $1.

c. *TR* = *dp* = (800 − 10*p*)*p* = 800*p* − 10*p*2

d. At $30 *TR* = 800(30) − 10(30)2 = 15,000

At $40 *TR* = 800(40) − 10(40)2 = 16,000

At $50 *TR* = 800(50) − 10(50)2 = 15,000

Total Revenue is maximized at the $40 price.

e. *d* = 800 − 10(40) = 400 units

*TR* = $16,000

12. **Modeling a Special Order Decision.** The O’Neill Shoe Manufacturing Company will produce a special-style shoe if the order size is large enough to provide a reasonable profit. For each special-style order, the company incurs a fixed cost of $2000 for the production setup. The variable cost is $60 per pair, and each pair sells for $80. **LO 4**

a. Let *x* indicate the number of pairs of shoes produced. Develop a mathematical model for the total cost of producing *x* pairs of shoes.

b. Let *P* indicate the total profit. Develop a mathematical model for the total profit realized from an order for *x* pairs of shoes.

c. How large must the shoe order be before O’Neill will break even?

Solutions:

a. *TC* = 2000 + 60*x*

b. *P* = 80*x* − (2000 + 60*x*) = 20*x* − 2000

c. Breakeven point is the value of *x* when *P* = 0.

Thus, 20*x* − 2000 = 0

20*x* = 2000

*x* = 100

13. **Breakeven Point for a Training Seminar.** Micromedia offers computer training seminars on a variety of topics. In the seminars each student works at a personal computer, practicing the particular activity that the instructor is presenting. Micromedia is currently planning a two-day seminar on the use of Microsoft Excel in statistical analysis. The projected fee for the seminar is $600 per student. The cost for the conference room, instructor compensation, lab assistants, and promotion is $9600. Micromedia rents computers for its seminars at a cost of $120 per computer per day. **LO 4**

a. Develop a model for the total cost to put on the seminar. Let *x* represent the number of students who enroll in the seminar.

b. Develop a model for the total profit if *x* students enroll in the seminar.

c. Micromedia has forecasted an enrollment of 30 students for the seminar. How much profit will be earned if their forecast is accurate?

d. Compute the breakeven point.

Solutions:

a. Total cost = 9600 + (2 ×120)*x* = 9600 + 240*x*

b. Total profit = total revenue − total cost

= 600*x* − (9600 + 240*x*)

= 360*x* − 9600

c. Total profit = 360(30) − 9600 = 1200

d. 360*x* − 9600 = 0

*x* = 9600/360 = 26.67

The breakeven point is between 26 and 27 students.

14. **Breakeven Point for a Textbook.** Eastman Publishing Company is considering publishing a paperback textbook on spreadsheet applications for business. The fixed cost of manuscript preparation, textbook design, and production setup is estimated to be $160,000. Variable production and material costs are estimated to be $6 per book. The publisher plans to sell the text to college and university bookstores for $46 each. **LO 4**

a. What is the breakeven point?

b. What profit or loss can be anticipated with a demand of 3800 copies?

c. With a demand of 3800 copies, what is the minimum price per copy that the publisher must charge to break even?

d. If the publisher believes that the price per copy could be increased to $50.95 and not affect the anticipated demand of 3800 copies, what action would you recommend? What profit or loss can be anticipated?

Solutions:

a. Profit = Revenue − Cost

= 46*x* − (160,000 + 6*x*)

= 40*x* − 160,000

40*x* − 160,000 = 0

40*x* = 160,000

*x* = 4000

Breakeven point = 4000

b. Profit = 40(3800) − 16,000 = −8000

Thus, a loss of $8000 is anticipated.

c. Profit = *px* − (160,000 + 6*x*)

= 3800*p* − (160,000 + 6(3800)) = 0

3800*p* = 182,800

*P* = 48.105 or $48.11

d. Profit = $50.95 (3800) − (160,000 + 6 (3800))

= $10,810

Probably go ahead with the project, although the $10,810 is only a 5.98% return on the total cost of $182,800.

15. **Breakeven Point for Stadium Luxury Boxes.** Preliminary plans are under way for the construction of a new stadium for a major league baseball team. City officials have questioned the number and profitability of the luxury corporate boxes planned for the upper deck of the stadium. Corporations and selected individuals may buy the boxes for $300,000 each. The fixed construction cost for the upper-deck area is estimated to be $4,500,000, with a variable cost of $150,000 for each box constructed. **LO 4**

a. What is the breakeven point for the number of luxury boxes in the new stadium?

b. Preliminary drawings for the stadium show that space is available for the construction of up to 50 luxury boxes. Promoters indicate that buyers are available and that all 50 could be sold if constructed. What is your recommendation concerning the construction of luxury boxes? What profit is anticipated?

Solutions:

a. Profit = 300,000*x* − (4,500,000 + 150,000*x*) = 0

150,000*x* = 4,500,000

*x* = 30

b. Build the luxury boxes.

Profit = 300,000 (50) − (4,500,000 + 150,000 (50))

= $3,000,000

16. **Modeling Investment Strategies.** Financial Analysts, Inc., is an investment firm that manages stock portfolios for a number of clients. A new client is requesting that the firm handle an $800,000 portfolio. As an initial investment strategy, the client would like to restrict the portfolio to a mix of the following two stocks:

|  |  |  |  |
| --- | --- | --- | --- |
| **Stock** | **Price/Share** | **Maximum  Estimated Annual Return/Share** | **Possible**  **Investment** |
| Oil Alaska | $50 | $6 | $500,000 |
| Southwest Petroleum | $30 | $4 | $450,000 |

Define *x* and *y* as follows. **LO 4**

*x* = number of shares of Oil Alaska

*y* = number of shares of Southwest Petroleum

a. Develop the objective function, assuming that the client desires to maximize the total annual return.

b. Show the mathematical expression for each of the following three constraints:

(1) Total investment funds available are $800,000.

(2) Maximum Oil Alaska investment is $500,000.

(3) Maximum Southwest Petroleum investment is $450,000.

*Note:* Adding the *x* $ 0 and *y* $ 0 constraints provides a linear programming model for the investment problem. A solution procedure for this model will be discussed in Chapter 2.

Solutions:

a. Max 6*x* + 4*y*

b. 50*x* + 30*y* ≤ 800,000

50*x* ≤ 500,000

30*y* ≤ 450,000

*x*, *y* ≥ 0

17. **Modeling an Inventory System.** Models of inventory systems frequently consider the relationships among a beginning inventory, a production quantity, a demand or sales, and an ending inventory. For a given production period *j*, define *s, x,* and *d* as follows. **LO 4**

*sj*–1 = ending inventory from the previous period (beginning inventory for period *j*)

*xj* = production quantity in period *j*

*dj* = demand in period *j*

*sj* = ending inventory for period *j*

a. Write the mathematical relationship or model that describes how these four variables are related.

b. What constraint should be added if production capacity for period *j* is given by *Cj*?

c. What constraint should be added if inventory requirements for period *j* mandate an ending inventory of at least *Ij*?

Solutions:

a. *sj* = *sj* − 1 + *xj* − *dj*

or *sj* − *sj* − 1 − *xj* + *dj* = 0

b. *xj* ≤ *cj*

c. *sj* ≥ *Ij*

18. **Blending Fuels.** Esiason Oil makes two blends of fuel by mixing oil from three wells, one each in Texas, Oklahoma, and California. The costs and daily availability of the oils are provided in the following table.

|  |  |  |
| --- | --- | --- |
| **Source of Oil** | **Cost per Gallon** | **Daily Gallons Available** |
| Texas well | 0.30 | 12,000 |
| Oklahoma well | 0.40 | 20,000 |
| California well | 0.48 | 24,000 |

Because these three wells yield oils with different chemical compositions, Esiason’s two blends of fuel are composed of different proportions of oil from its three wells. Blend A must be composed of at least 35% of oil from the Texas well, no more than 50% of oil from the Oklahoma well, and at least 15% of oil from the California well. Blend B must be composed of at least 20% of oil from the Texas well, at least 30% of oil from the Oklahoma well, and no more than 40% of oil from the California well.

Each gallon of Blend A can be sold for $3.10 and each gallon of Blend B can be sold for $3.20. Long-term contracts require at least 20,000 gallons of each blend to be produced.

Define *x, y,* and *i* as follows. **LO 4**

*xi* = number of gallons of oil from well *i* used in production of Blend A

*yi* = number of gallons of oil from well *i* used in production of Blend B

*i* = 1 for the Texas well, 2 for the Oklahoma well, 3 for the California well

a. Develop the objective function, assuming that the client desires to maximize the total daily profit.

b. Show the mathematical expression for each of the following three constraints:

(1) Total daily gallons of oil available from the Texas well is 12,000.

(2) Total daily gallons of oil available from the Oklahoma well is 20,000.

(3) Total daily gallons of oil available from the California well is 24,000.

c. Should this problem include any other constraints? If so, express them mathematically in terms of the decision variables.

Solutions:

a. Maximize (3.10 − 0.30)*x*1 + (3.10 − 0.40) *x*2 + (3.10 − 0.48)*x*3 + (3.20 − 0.30)*y*1 + (3.20 − 0.40)*y*2 +(3.20 − 0.48)*y*3

= Maximize 2.80*x*1 + 2.70 *x*2 + 2.62*x*3 +2.90*y*1 + 2.80*y*2 +2.72*y*3

b. (1) *x*1 + *y*1 ≤ 12,000

(2) *x*2 + *y*2 ≤ 20,000

(3) *x*3 + *y*3 ≤ 24,000

c. *x*1 ≥ .35(*x*1 + *x*2 + *x*3) or .65*x*1 − .35*x*2 − .35*x*3 ≥ 0 (Blend A must be composed of at least 35% of oil from the Texas well.)

*x*2 ≤ .50(*x*1 + *x*2 + *x*3) or −.50*x*1 + .50*x*2 − .50*x*3 ≤ 0 (Blend A must be composed of no more than 50% of oil from the Oklahoma well.)

*x*3 ≥ .15(*x*1 + *x*2 + *x*3) or −.15*x*1 − .15*x*2 + .85*x*3 ≥ 0 (Blend A must be composed of at least 15% of oil from the California well.)

*y*1 ≥ .20(*y*1 + *y*2 + *y*3) or .80*y*1 − .20*y*2 − .20*y*3 ≥ 0 (Blend B must be composed of at least 20% of oil from the Texas well.)

*y*2 ≥ .30(*y*1 + *y*2 + *y*3) or −.30*y*1 + .70*y*2 − .30*y*3 ≥ 0 (Blend B must be composed of at least 30% of oil from the Oklahoma well.)

*y*3 ≤ .40(*y*1 + *y*2 + *y*3) or −.40*y*1 − .40*y*2 + .60*y*3 ≤ 0 (Blend B must be composed of no more than 40% of oil from the California well.)

*x*1 + *x*2 + *x*3 ≥ 20,000 (Long-term contracts require at least 20,000 gallons of Blend A to be produced.)

*y*1 + *y*2 + *y*3 ≥ 20,000 (Long-term contracts require at least 20,000 gallons of Blend B to be produced.)

19. **Modeling Cabinet Production.** Brooklyn Cabinets is a manufacturer of kitchen cabinets. The two cabinetry styles manufactured by Brooklyn are contemporary and farmhouse. Contemporary style cabinets sell for $90 and farmhouse style cabinets sell for $85. Each cabinet produced must go through carpentry, painting, and finishing processes. The following table summarizes how much time in each process must be devoted to each style of cabinet.

|  |  |  |  |
| --- | --- | --- | --- |
| **Style** | **Carpentry** | **Hours per Process**  **Painting** | **Finishing** |
| Contemporary | 2.0 | 1.5 | 1.3 |
| Farmhouse | 2.5 | 1.0 | 1.2 |

Carpentry costs $15 per hour, painting costs $12 per hour, and finishing costs $18 per hour; and the weekly number of hours available in the processes is 3000 in carpentry, 1500 in painting, and 1500 in finishing. Brooklyn also has a contract that requires the company to supply one of its customers with 500 contemporary cabinets and 650 farmhouse style cabinets each week.

Define *x* and *y* as follows. **LO 4**

*x* = the number of contemporary style cabinets produced each week

*y* = the number of farmhouse style cabinets produced each week

a. Develop the objective function, assuming that Brooklyn Cabinets wants to maximize the total weekly profit.

b. Show the mathematical expression for each of the constraints on the three processes.

c. Show the mathematical expression for each of Brooklyn Cabinets’ contractual agreements.

Solutions:

a. Profit per contemporary cabinet is $90 − [2.0($15) + 1.5($12) + 1.3($18)] = $18.60.

Profit per farmhouse cabinet is $85 − [2.5($15) + 1.0($12) + 1.2($18)] = $13.90.

So the objective function is maximize 18.6*x* + 13.9*y*.

b. 2.0*x*1 + 2.5*y*1 ≤ 3000 hours available in carpentry

1.5*x*2 + 1.0*y*2 ≤ 1500 hours available in painting

1.3*x*3 + 1.2*y*3 ≤ 1500 hours available in finishing

c. *x* ≥ 500

*y* ≥ 650

20. **Modeling the Promotion Mix for a Movie.** PromoTime, a local advertising agency, has been hired to promote the new adventure film *Tomb Raiders* starring Angie Harrison and Joe Lee Ford. The agency has been given a $100,000 budget to spend on advertising for the movie in the week prior to its release, and the movie’s producers have dictated that only local television ads and locally targeted Internet ads will be used. Each television ad costs $500 and reaches an estimated 7000 people, and each Internet ad costs $250 and reaches an estimated 4000 people. The movie’s producers have also dictated that, in order to avoid saturation, no more than 20 television ads will be placed. The producers have also stipulated that, in order to reach a critical mass, at least 50 Internet ads will be placed. Finally, the producers want at least one-third of all ads to be placed on television.

Define *x* and *y* as follows. **LO 4**

*x* = the number of television ads purchased

*y* = the number of Internet ads purchased

a. Develop the objective function, assuming that the movie’s producers want to reach the maximum number of people possible.

b. Show the mathematical expression for the budget constraint.

c. Show the mathematical expression for the maximum number of 20 television ads to be used.

d. Show the mathematical expression for the minimum number of Internet ads to be used.

e. Show the mathematical expression for the stipulated ratio of television ads to Internet ads.

f. Carefully review the constraints you created in part (b), part (c), and part (d). Does any aspect of these constraints concern you? If so, why?

Solutions:

a. Maximize 7000*x* + 4000*y*

b. 500*x* + 250*y* ≤ 100,000

c. *x* ≤ 20

d. *y* ≥ 50

e. , or 2*x* − *y* ≥ 0

f. If the constraints for the maximum number of television ads to be used from part(c) and the minimum number of Internet ads to be used from part (d) are both satisfied, then television ads can be at most . That is, the constraint for the stipulated ratio of television ads to Internet ads cannot be satisfied. Therefore, the problem as stated is infeasible.

# Case Problem: Scheduling a Youth Soccer League

Caridad Suárez, head of the Boone County Recreational Department, must develop a schedule of games for a youth soccer league that begins its season at 4:00 p.m. tomorrow. Eighteen teams signed up for the league, and each team must play every other team over the course of the 17-week season (each team plays one game per week). Caridad thought it would be fairly easy to develop a schedule, but after working on it for a couple of hours, she has been unable to come up with a schedule. Because Caridad must have a schedule ready by tomorrow afternoon, she asked you to help her. A possible complication is that one of the teams told Caridad that it may have to cancel for the season. This team told Caridad it will let her know by 1:00 p.m. tomorrow whether it will be able to play this season. **LO 4**

**Managerial Report**

Prepare a report for Caridad Suárez. Your report should include, at a minimum, the following items:

1. A schedule that will enable each of the 18 teams to play every other team over the 17-week season.

2. A contingency schedule that can be used if the team that contacted Caridad decides to cancel for the season.

Solutions:

**Note to Instructor:** This case problem illustrates the value of the rational management science approach. The problem is easy to understand and, at first glance, appears simple. But, most students will have trouble finding a solution. The solution procedure suggested involves decomposing a larger problem into a series of smaller problems that are easier to solve. The case provides students with a good first look at the kinds of problems where management science is applied in practice.

**Solution:** Scheduling problems such as this occur frequently, and are often difficult to solve. The typical approach is to use trial and error. An alternative approach involves breaking the larger problem into a series of smaller problems. We show how this can be done here using what we call the Red, White, and Blue algorithm.

Suppose we break the 18 teams up into three divisions, referred to as the Red, White, and Blue divisions. The six teams in the Red division can then be identified as R1, R2, R3, R4, R5, R6; the six teams in the White division can be identified as W1, W2, …, W6; and the six teams in the Blue division can be identified as B1, B2, …, B6. We begin by developing a schedule for the first 5 weeks of the season so that each team plays every other team in its own division. This can be done fairly easily by trial and error. Shown below is the first 5-week schedule for the Red division.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Week 1** | **Week 2** | **Week 3** | **Week 4** | **Week 5** |
| R1 vs. R2 | R1 vs. R3 | R1 vs. R4 | R1 vs. R5 | R1 vs. R6 |
| R3 vs. R4 | R2 vs. R5 | R2 vs. R6 | R2 vs. R4 | R2 vs. R3 |
| R5 vs. R6 | R4 vs. R6 | R3 vs. R5 | R3 vs. R6 | R4 vs. R5 |

Similar five-week schedules can be developed for the White and Blue divisions by replacing the R in the above table with a W or a B.

To develop the schedule for the next three weeks, we create three new six-team divisions by pairing three of the teams in each division with three of the teams in another division; for example, (R1, R2, R3, W1, W2, W3), (B1, B2, B3, R4, R5, R6), and (W4, W5, W6, B4, B5, B6). Within each of these new divisions, games can be scheduled for three weeks without any teams playing a team they have played before. For instance, a three-week schedule for the first of these divisions is shown below:

|  |  |  |
| --- | --- | --- |
| **Week 6** | **Week 7** | **Week 8** |
| R1 vs. W1 | R1 vs. W2 | R1 vs. W3 |
| R2 vs. W2 | R2 vs. W3 | R2 vs. W1 |
| R3 vs. W3 | R3 vs. W1 | R3 vs. W2 |

A similar three-week schedule can be easily set up for the other two new divisions. This will provide us with a schedule for the first 8 weeks of the season.

For the final nine weeks, we continue to create new divisions by pairing three teams from the original Red, White, and Blue divisions with three teams from the other divisions that they have not yet been paired with. Then a three-week schedule is developed as above. Shown below is a set of divisions for the next nine weeks.

**Weeks 9 to 11**

(R1, R2, R3, W4, W5, W6) (W1, W2, W3, B1, B2, B3) (R4, R5, R6, B4, B5, B6)

**Weeks 12 to 14**

(R1, R2, R3, B1, B2, B3) (W1, W2, W3, B4, B5, B6) (W4, W5, W6, R4, R5, R6)

**Weeks 15 to 17**

(R1, R2, R3, B4, B5, B6) (W1, W2, W3, R4, R5, R6) (W4, W5, W6, B1, B2, B3)

This Red, White, and Blue scheduling procedure provides a schedule with every team playing every other team over the 17-week season. If one of the teams should cancel, the schedule can be modified easily. Designate the team that cancels, say R4, as the Bye team. Then whichever team is scheduled to play team R4 will receive a Bye in that week. With only 17 teams a Bye must be scheduled for one team each week.

This same scheduling procedure can obviously be used for scheduling any types of teams or any other kinds of matches involving 17 or 18 teams. Modifications of the Red, White, and Blue algorithm can be employed for 15 or 16 team leagues and other numbers of teams.