The specifications for Golding-Grow are as follows: (1) E-11 must constitute at least 15% of the blend; (2) C-92 and C-30 must together constitute at least 45% of the blend; (3) D-21 and C-92 can together constitute no more than 30% of the blend; and (4) Golding-Grow is packaged and sold in 50-pound bags.

(a) Formulate an LP problem to determine what blend of the four chemicals will allow Golding to minimize the cost of a 50-pound bag of the fertilizer.

(b) Solve using a computer to find the best solution.

Q 7-45 Raptor Fuels produces three grades of gasoline—Regular, Premium, and Super. All of these are produced by blending two types of crude oil—Crude A and Crude B. The two types of crude contain specific ingredients which help in determining the octane rating of gasoline. The important ingredients and the costs are contained in the following table:

	CRUDE A	CRUDE B
Cost per gallon	$0.42	$0.47
Ingredient 1	40%	52%
Other ingredients	60%	48%

In order to achieve the desired octane ratings, at least 41% of Regular gasoline should be Ingredient 1; at least 44% of Premium gasoline must be Ingredient 1, and at least 48% of Super gasoline must be Ingredient 1. Due to current contract commitments, Raptor Fuels must produce as least 20,000 gallons of Regular, at least 15,000 gallons of Premium, and at least 10,000 gallons of Super. Formulate a linear program that could be used to determine how much of Crude A and Crude B should be used in each of the gasolines to meet the demands at the minimum cost. What is the minimum cost? How much of Crude A and Crude B are used in each gallon of the different types of gasoline?

Internet Homework Problems

See our Internet home page, at www.pearsonhighered.com/render, for additional homework problems, Problems 7-46 to 7-50.

Case Study

Mexicana Wire Works

Ron Garcia felt good about his first week as a management trainee at Mexicana Wire Winding, Inc. He had not yet developed any technical knowledge about the manufacturing process, but he had toured the entire facility, located in the suburbs of Mexico City, and had met many people in various areas of the operation.

Mexicana, a subsidiary of Westover Wire Works, a Texas firm, is a medium-sized producer of wire windings used in making electrical transformers. Carlos Alverez, the production control manager, described the windings to Garcia as being of standardized design. Garcia's tour of the plant, laid out by process type (see Figure 7.20), followed the manufacturing sequence for the windings: drawing, extrusion, winding, inspection, and packaging. After inspection, good product is packaged and sent to finished product storage; defective product is stored separately until it can be reworked.

On March 8, Vivian Espania, Mexicana's general manager, stopped by Garcia's office and asked him to attend a staff meeting at 1:00 P.M.

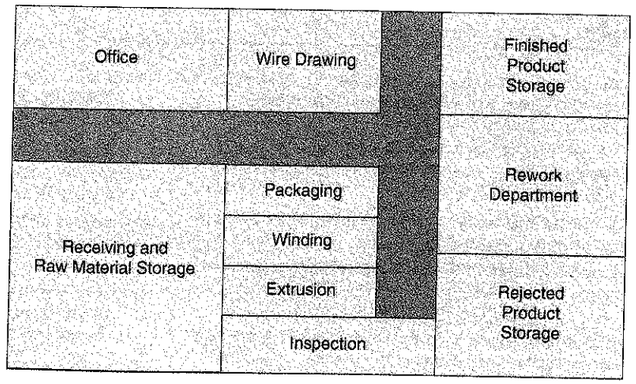
"Let's get started with the business at hand," Vivian said, opening the meeting. "You all have met Ron Garcia, our new management trainee. Ron studied operations management in his MBA program in southern California, so I think he is competent to help us with a problem we have been discussing for a long time without resolution. I'm sure that each of you on my staff will give Ron your full cooperation."

Vivian turned to José Arroyo, production control manager. "José, why don't you describe the problem we are facing?"

"Well," José said, "business is very good right now. We are booking more orders than we can fill. We will have some new equipment on line within the next several months, which will take care of our capacity problems, but that won't help us in April. I have located some retired employees who used to work in the drawing department, and I am planning to bring them in as temporary employees in April to increase capacity there. Because we are planning to refinance some of our long-term debt, Vivian wants our profits to look as good as possible in April. I'm having a hard time figuring out which orders to run and which to back order so that I can make the bottom line look as good as possible. Can you help me with this?"

Garcia was surprised and apprehensive to receive such an important, high-profile assignment so early in his career.

FIGURE 7.20
Mexicana Wire Winding, Inc.



Recovering quickly, he said, "Give me your data and let me work with it for a day or two."

April Orders

Product W0075C	1,400 units
Product W0033C	250 units
Product W0005X	1,510 units
Product W0007X	1,116 units

Note: Vivian Espania has given her word to a key customer that we will manufacture 600 units of product W0007X and 150 units of product W0075C for him during April

Standard Cost

PRODUCT	MATERIAL	LABOR	OVERHEAD	SELLING PRICE
W0075C	$33.00	$ 9.90	$23.10	$100.00
W0033C	25.00	7.50	17.50	80.00
W0005X	35.00	10.50	24.50	130.00
W0007X	75.00	11.25	63.75	175.00

Selected Operating Data

Average output per month = 2,400 units

Average machine utilization = 63%

Average percentage of production set to rework department = 5% (mostly from Winding Department)

Average no. of rejected units awaiting rework = 850 (mostly from Winding Department)

Plant Capacity (Hours)

DRAWING	EXTRUSION	WINDING	PACKAGING
4,000	4,200	2,000	2,300

Note: Inspection capacity is not a problem; we can work overtime, as necessary, to accommodate any schedule.

Bill of Labor (Hours/Unit)

PRODUCT	DRAWING	EXTRUSION	WINDING	PACKAGING
W0075C	1.0	1.0	1.0	1.0
W0033C	2.0	1.0	3.0	0.0
W0005X	0.0	4.0	0.0	3.0
W0007X	1.0	1.0	0.0	2.0

Discussion Questions

1. What recommendations should Ron Garcia make, with what justification? Provide a detailed analysis with charts, graphs, and computer printouts included.
2. Discuss the need for temporary workers in the drawing department.
3. Discuss the plant layout.

Source: Professor Victor E. Sower, Sam Houston State University. This case material is based on an actual situation, with names and data altered for confidentiality.

Internet Case Study

See our Internet home page, at www.pearsonhighered.com/render, for this additional case study: Agri Chem Corporation. This case involves a company's response to an energy shortage.

risk.) The expected return and the betas for five stocks are as follows:

STOCK	1	2	3	4	5
Expected return (%)	11.0	9.0	6.5	15.0	13.0
Beta	1.20	0.85	0.55	1.40	1.25

Daniel would like to minimize the beta of the stock portfolio (calculated using a weighted average of the amounts put into the different stocks) while maintaining an expected return of at least 11%. Since future conditions may change, Daniel has decided that no more than 35% of the portfolio should be invested in any one stock.

(a) Formulate this as a linear program. (*Hint*: Define the variables to be the proportion of the total investment that would be put in each stock. Include a constraint that restricts the sum of these variables to be 1.)

(b) Solve this problem. What are the expected return and beta for this portfolio?

8-23 ***(Airline fuel problem)*** Coast-to-Coast Airlines is investigating the possibility of reducing the cost of fuel purchases by taking advantage of lower fuel costs in certain cities. Since fuel purchases represent a substantial portion of operating expenses for an airline, it is important that these costs be carefully monitored. However, fuel adds weight to an airplane, and consequently, excess fuel raises the cost of getting from one city to another. In evaluating one particular flight rotation, a plane begins in Atlanta, flies from Atlanta to Los Angeles, from Los Angeles to Houston, from Houston to New Orleans, and from New Orleans to Atlanta. When the plane arrives in Atlanta, the flight rotation is said to have been completed, and then it starts again. Thus, the fuel on board when the flight arrived in Atlanta must be taken into consideration when the flight begins. Along each leg of this route, there is a minimum and a maximum amount of fuel that may be carried. This and additional information is provided in the table on this page.

The regular fuel consumption is based on the plane carrying the minimum amount of fuel. If more than this is carried, the amount of fuel consumed is higher. Specifically, for each 1,000 gallons of fuel above the minimum, 5% (or 50 gallons per 1,000 gallons of extra fuel) is lost due to excess fuel consumption. For example, if 25,000 gallons of fuel were on board when the plane takes off from Atlanta, the fuel consumed on this route would be 12 + 0.05 = 12.05 thousand gallons. If 26 thousand gallons were on board, the fuel consumed would be increased by another 0.05 thousand, for a total of 12.1 thousand gallons.

Formulate this as an LP problem to minimize the cost. How many gallons should be purchased in each city? What is the total cost of this?

Data for Problem 8-23

LEG	MINIMUM FUEL REQUIRED (1,000 GAL.)	MAXIMUM FUEL ALLOWED (1,000 GAL.)	REGULAR FUEL CONSUMPTION (1,000 GAL.)	FUEL PRICE PER GALLON
Atlanta–Los Angeles	24	36	12	$4.15
Los Angeles–Houston	15	23	7	$4.25
Houston–New Orleans	9	17	3	$4.10
New Orleans–Atlanta	11	20	5	$4.18

Internet Homework Problems

See our Internet home page, at www.pearsonhighered.com/render, for additional homework problems, Problems 8-24 to 8-26.

Case Study

Chase Manhattan Bank

The workload in many areas of bank operations has the characteristics of a nonuniform distribution with respect to time of day. For example, at Chase Manhattan Bank in New York, the number of domestic money transfer requests received from customers, if plotted against time of day, would appear to have the shape of an inverted U curve with the peak around 1 P.M. For efficient use of resources, the personnel available should, therefore, vary correspondingly. Figure 8.2 shows a typical workload curve and corresponding personnel requirements at different hours of the day.

A variable capacity can be achieved effectively by employing part-time personnel. Because part-timers are not entitled to all the fringe benefits, they are often more economical than full-time employees. Other considerations, however, may limit the extent to which part-time people can be hired in a given department. The problem is to find an optimum workforce schedule that would meet personnel requirements at any given time and also be economical.

Some of the factors affecting personnel assignment are listed here:

1. By corporate policy, part-time personnel hours are limited to a maximum of 40% of the day's total requirement.
2. Full-time employees work for 8 hours (1 hour for lunch included) per day. Thus, a full-timer's productive time is 35 hours per week.
3. Part-timers work for at least 4 hours per day but less than 8 hours and are not allowed a lunch break.
4. Fifty percent of the full-timers go to lunch between 11 A.M. and noon, and the remaining 50% go between noon and 1 P.M.
5. The shift starts at 9 A.M. and ends at 7 P.M. (i.e., overtime is limited to 2 hours). Any work left over at 7 P.M. is considered holdover for the next day.
6. A full-time employee is not allowed to work more than 5 hours overtime per week. He or she is paid at the normal rate for overtime hours—*not* at one-and-a-half times the normal rate applicable to hours in excess of 40 per week. Fringe benefits are not applied to overtime hours.

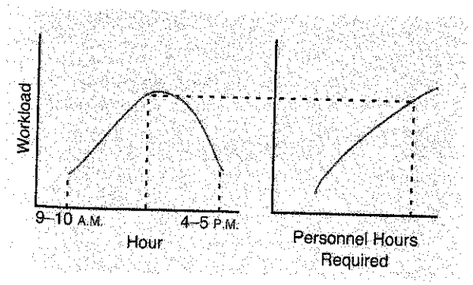
In addition, the following costs are pertinent:

1. The average cost per full-time personnel hour (fringe benefits included) is $10.11.
2. The average cost per overtime personnel hour for full-timers (straight rate excluding fringe benefits) is $8.08.
3. The average cost per part-time personnel hour is $7.82.

The personnel hours required, by hour of day, are given in Table 8.9.

The bank's goal is to achieve the minimum possible personnel cost subject to meeting or exceeding the hourly workforce requirements as well as the constraints on the workers listed earlier.

FIGURE 8.2



Discussion Questions

1. What is the minimum-cost schedule for the bank?
2. What are the limitations of the model used to answer question 1?
3. Costs might be reduced by relaxing the constraint that no more than 40% of the day's requirement be met by part-timers. Would changing the 40% to a higher value significantly reduce costs?

Source: Adapted from Shyam L. Moondra. "An L. P. Model for Work Force Scheduling for Banks," *Journal of Bank Research* (Winter 1976): 299–301.

TABLE 8.9 Workforce Requirements

TIME PERIOD	NUMBER OF PERSONNEL REQUIRED
9–10 A.M.	14
10–11	25
11–12	26
12–1 P.M.	38
1–2	55
2–3	60
3–4	51
4–5	29
5–6	14
6–7	9

Bibliography

See the Bibliography at the end of Chapter 7.