DISCUSSION QUESTIONS AND PROBLEMS

Discussion Questions

2-1 It is important to understand the assumptions underlying the use of any quantitative analysis model. What are the assumptions and requirements for an LP model to be formulated and used?

2-2 It has been said that each LP problem that has a feasible region has an infinite number of solutions. Explain.

2-3 Under what condition is it possible for an LP problem to have more than one optimal solution?

2-4 Under what condition is it possible for an LP problem to have an unbounded solution?

2-5 Develop your own set of constraint equations and inequalities and use them to illustrate graphically each of the following conditions:

(a) An unbounded problem
(b) An infeasible problem
(c) A problem containing redundant constraints

2-6 The production manager of a large Cincinnati manufacturing firm once made the statement, "I would like to use LP, but it's a technique that operates under conditions of certainty. My plant doesn't have that certainty; it's a world of uncertainty. So LP can't be used here." Do you think this statement has any merit? Explain why the manager may have said it.

2-7 The mathematical relationships that follow were formulated by an operations research analyst at the Smith-Lawton Chemical Company. Which ones are invalid for use in an LP problem? Why?

$$\text{Maximize profit} = 4X_1 + 3X_1X_2 + 8X_2 + 5X_3$$

subject to the constraints

$$\begin{aligned} 2X_1 + X_2 + 2X_3 &\leq 50 \\ X_1 - 4X_2 &\geq 6 \\ 1.5X_1^2 + 6X_2 + 3X_3 &\geq 21 \\ 19X_2 - 0.33X_3 &= 17 \\ 5X_1 + 4X_2 + 3\sqrt{X_3} &\leq 80 \end{aligned}$$

2-8 How do computers aid in solving LP problems today?

2-9 Explain why knowing how to use Excel to set up and solve LP problems may be beneficial to a manager.

2-10 What are the components of defining a problem in Excel so that it can be solved using Solver?

2-11 How is the slack (or surplus) calculated for a constraint? How is it interpreted?

2-12 What is an unbounded solution? How does Solver indicate that a problem solution is unbounded?

Problems

2-13 Solve the following LP problem by using the graphical procedure and then by using Excel:

$$\text{Maximize } 5X + 3Y$$

subject to the constraints

$$\begin{aligned} 5X + 2Y &\leq 40 \\ 3X + 6Y &\leq 48 \\ X &\leq 7 \\ 2X - Y &\geq 3 \\ X, Y &\geq 0 \end{aligned}$$

2-14 Solve the following LP problem by using the graphical procedure and then by using Excel.

$$\text{Minimize } X + 2Y$$

subject to the constraints

$$\begin{aligned} X + 3Y &\geq 90 \\ 8X + 2Y &\geq 160 \\ 3X + 2Y &\geq 120 \\ Y &\leq 70 \\ X, Y &\geq 0 \end{aligned}$$

2-15 Solve the following LP problem by using the graphical procedure and then by using Excel:

$$\text{Minimize } 4X + 7Y$$

subject to the constraints

$$\begin{aligned} 3X + 7Y &\geq 231 \\ 10X + 2Y &\geq 200 \\ 2Y &\geq 45 \\ 2X &\leq 75 \\ X, Y &\geq 0 \end{aligned}$$

2-16 Solve the following LP problem by using the graphical procedure and then by using Excel:

$$\text{Maximize } X + Y$$

subject to the constraints

$$\begin{aligned} 3X + 6Y &\leq 29 \\ 7X + Y &\leq 20 \\ 3X - Y &\geq 1 \\ X, Y &\geq 0 \end{aligned}$$

2-17 Solve the following LP problem by using the graphical procedure and then by using Excel:

$$\text{Maximize } 7X+4Y$$

subject to the constraints

$$\begin{aligned} 9X + 8Y &\leq 72 \\ 3X + 9Y &\geq 27 \\ 9X - 15Y &\geq 0 \\ X, Y &\geq 0 \end{aligned}$$

2-18 Solve the following LP problem by using the graphical procedure and then by using Excel:

$$\text{Minimize } 3X + 7Y$$

subject to the constraints

$$\begin{aligned} 9X + 3Y &\geq 36 \\ 4X + 5Y &\geq 40 \\ X - Y &\leq 0 \\ 2X &\leq 13 \\ X, Y &\geq 0 \end{aligned}$$

2-19 Consider the following four LP formulations. Using a graphical approach in each case, determine

(a) which formulation has more than one optimal solution.
(b) which formulation has an unbounded solution.
(c) which formulation is infeasible.
(d) which formulation has a unique optimal solution.

Formulation 1

Maximize $3X+7Y$

subject to

$$\begin{aligned} 2X + Y &\leq 6 \\ 4X + 5Y &\leq 20 \\ 2Y &\leq 7 \\ 2X &\geq 7 \\ X, Y &\geq 0 \end{aligned}$$

Formulation 2

Maximize $3X + 6Y$

subject to

$$\begin{aligned} 7X + 6Y &\leq 42 \\ X + 2Y &\leq 10 \\ X &\leq 4 \\ 2Y &\leq 9 \\ X, Y &\geq 0 \end{aligned}$$

Formulation 3

$$3X + 6Y \geq 42$$

subject to

$$\begin{aligned} X + 2Y &\geq 12 \\ 8X + 7Y &\geq 56 \\ 2Y &\geq 5 \\ X &\leq 9 \\ X, Y &\geq 0 \end{aligned}$$

Formulation 4

Maximize $3X + 4Y$

subject to

$$\begin{aligned} 3X + 7Y &\leq 21 \\ 2X + Y &\leq 6 \\ X + Y &\geq 2 \\ 2X &\geq 2 \\ X, Y &\geq 0 \end{aligned}$$

2-20 Set up and solve the following LP problem, which involves three decision variables, by using Excel:

$$\text{Maximize } 28A + 41B + 38C$$

subject to the constraints

$$\begin{aligned} 10A + 15B - 8C &\leq 610 \\ 0.4(A + B + C) &\leq A \\ A &\leq 3B \\ B &\geq C \\ A, B, C &\geq 0 \end{aligned}$$

Note: Problems 2-21 to 2-38 each involve only two decision variables. Therefore, at the discretion of the instructor, they can be solved by using the graphical method, Excel, or both.

2-21 Personal Mini Warehouses (PMW) is planning to expand its successful Orlando business into Tampa. In doing so, the company must determine how many storage sheds of each size—large and small—to build in its 8,000-square-00 facility. Each large shed is 150 square feet in size, requires $1 per week in advertising, and rents for $50 per week. Each small shed is 50 square feet in size, requires $1 per week in advertising, and rents for $20 per week. PMW has a weekly advertising budget of $100 and estimates that it can rent no more than 40 large sheds in any given week. Formulate PMW's problem as a linear program. Solve by using the graphical procedure, and then by using Excel.

2-22 A small magazine publisher wants to determine the best combination of two possible magazines to print for the month of July. *Backyard* magazine, which he has published for years, is a steady seller. The publisher wants to make sure he prints at least 400 copies to meet his demand from the newsstands. *Porch* is a new venture and has received the benefit of a great deal of advance publicity. The publisher is hoping that by positioning it near *Backyard*, he will pick up some spillover demand from his regular readers. Also, he is hoping that the advertising campaign will bring in a new type of reader from a potentially very lucrative market. He wants to print at least 300 copies of *Porch*. The cover price for *Backyard* is $3.50; he is pricing *Porch* at $4.50 because other magazines in this market seem to be able to command this type of higher price. The publisher has 36 hours of printing time available for this production run. He also has 30 hours in the collation department, where the magazines are actually assembled. Each *Backyard* requires 2.5 minutes per copy to print and 1.8 minutes per copy to collate. Each *Porch* requires 2 minutes to print and 2 minutes to collate. How many of each magazine should the publisher print to maximize his revenue?

2-23 An architect wishes to design the safety deposit room for a bank safe. He plans to place safety deposit boxes approximately 6 feet high along the length of the room's walls, 40 feet. The bank has asked him to plan for two sizes of box: large and small. Large boxes (which consume 122.4 square inches) will rent for $40 per year. Small boxes (which consume 72 square inches) will rent for $30 per year. The bank has asked for at least 350 total boxes, of which at least 80 boxes should be large. The bank hopes to maximize its revenue for safety deposit boxes. How many

boxes of each size should the architect's design provide?

2-24 The Sweet Smell Fertilizer Company markets bags of manure labeled "not less than 60 pounds dry weight." The packaged manure is a combination of compost and sewage wastes. Each pound of compost costs Sweet Smell $0.05 and has a fertilizer rating of 2 units. Each pound of sewage costs $0.04 and has a fertilizer rating of 1 unit. To provide good-quality fertilizer, each bag should contain at least 35 pounds of compost, not more than 40 pounds of sewage, and have a total fertilizer rating of at least 100 units. Determine the lowest-cost blend of compost and sewage in each bag.

2-25 National Credit Union has $250,000 available to invest in a 12-month commitment. The money can be placed in treasury notes (with a return of 8% and a risk score of 2) or in municipal bonds (with a return of 9% and a risk score of 3). Credit union regulations require diversification to the extent that between 50% and 70% of the total investment must be placed in treasury notes. Also, due to past defaults in such municipalities as Cleveland and New York, it is decided that the average risk score of the total investment should be no more than 2.42. How much should National Credit Union invest in each security so as to maximize its return on investment?

2-26 The advertising agency promoting the new Breem dishwashing detergent wants to get the best exposure possible for the product within the $95,200 advertising budget ceiling placed upon it. To do so, the agency needs to decide how much of the budget to spend on each of its two most effective media: (1) television spots during the afternoon hours and (2) large ads in the city's Sunday newspaper. Each television spot costs $3,200; each Sunday newspaper ad costs $1,300. The expected exposure, based on industry ratings, is 30,000 viewers for each television commercial and 20,000 readers for each newspaper advertisement. The agency director, Mavis Early, knows from experience that is it important to use both media in order to reach the broadest spectrum of potential Breem customers. She decides that at least 5 but no more than 10 television spots should be ordered and that the number of newspaper ads should be no more than 8 times the number of television spots. How many times should each of the two media be used to obtain maximum exposure while staying within the budget?

2-27 The Electrocomp Corporation manufactures two electrical products: air conditioners and large fans. The assembly process for each is similar in that both require a certain amount of wiring, drilling, and assembly. Each air conditioner takes 3 hours of wiring, 2 hours of drilling, and 1.5 hours of assembly. Each fan must go through 2 hours of wiring, 1 hour of drilling, and 0.5 hours of assembly. During the next production period, 240 hours of wiring time, 140 hours of drilling time, and 100 hours of assembly time are available. Each air conditioner sold yields a profit of $25. Each fan assembled can be sold for a $15 profit. Formulate and solve Electrocomp's problem to find the best combination of air conditioners and fans that yields the highest profit.

2-28 Electrocomp's management realizes that it forgot to include two critical constraints (see Problem 2-27). In particular, management decides that to ensure an adequate supply of air conditioners for a contract, at least 50 air conditioners should be manufactured. Because Electrocomp incurred an oversupply of fans the preceding period, management also insists that no more than 30 fans be produced during this production period. Resolve Electrocomp's problem to find the new optimal solution.

2-29 The Marriott Tub Company manufactures two lines of bathtubs, called model A and model B. Every tub requires blending a certain amount of steel and zinc; the company has available a total of 24,500 pounds of steel and 6,000 pounds of zinc. Each model A bathtub requires a mixture of 120 pounds of steel and 20 pounds of zinc, and each yields a profit to the firm of $90. Each model B tub produced can be sold for a profit of $70; it requires 100 pounds of steel and 30 pounds of zinc. To maintain an adequate supply of both models, Marriott would like the number of model A tubs made to be no more than 5 times the number of model B tubs. Find the best product mix of bathtubs.

2-30 The Outdoor Furniture Corporation manufactures two products, benches and picnic tables, for use in yards and parks. The firm has two main resources: its carpenters (labor force) and a supply of redwood for use in the furniture. During the next production cycle, 1,000 hours of labor are available under a union agreement. The firm also has a stock of 3,500 feet of good-quality redwood. Each bench that Outdoor Furniture produces requires 4 labor hours and 10 feet of redwood; each picnic table takes 6 labor hours and 35 feet of redwood. Completed benches will yield a profit of $9 each, and tables will result in a profit of $20 each. Because most customers usually buy tables and benches at the same time, the number of benches made should be at least twice as large as the number of tables made. How many benches and tables should Outdoor Furniture produce to obtain the largest possible profit?

2-31 The Dean of the Western Institute of Business must plan the school's course offerings for the next term. Student demands make it necessary to offer at least 20 core courses (each of which counts for 3 credit hours) and 20 elective courses (each of which counts for 4 credit hours) in the term. Faculty contracts also dictate that a total of at least 60 core and elective courses and at least 205 total credit hours be offered. Each core course taught costs the college an average of $2,600 in faculty wages, and each elective course costs $3,000. How many core and elective courses should be taught so that total faculty salaries are kept to a minimum?

2-32 MSA Computer Corporation manufactures two models of computer network routers, the Alpha 4 and the Beta 5. The firm employs five technicians, working 156 hours each per month, on its assembly line. Management insists that full employment (i.e., *all* 156

hours of time) be maintained for each worker during next month's operations. It requires 20 labor hours to assemble each Alpha 4 model and 25 labor hours to assemble each Beta 5 model. MSA wants to see at least 35 total routers made, and it wants the number of Beta 5 routers made to be no more than the number of Alpha 4 routers made. Alpha 4 routers generate a $1,200 profit per unit, and Beta 5 routers yield $1,800 each. Determine the most profitable number of each model of router to produce during the coming month.

2-33 The seasonal yield of olives in a Piraeus, Greece, vineyard is greatly influenced by a process of branch pruning. If olive trees are pruned every two weeks, output is increased. The pruning process, however, requires considerably more labor than permitting the olives to grow on their own, and it results in smaller-size olives. It also, though, permits olive trees to be spaced closer together. The yield of 1 barrel of olives by pruning requires 5 hours of labor and 1 acre of land. The production of a barrel of olives by the normal process requires only 2 labor hours but takes 2 acres of land. An olive grower has 250 hours of labor available and a total of 150 acres for growing. Because of the olive size difference, a barrel of olives produced on pruned trees sell for $20, whereas a barrel of regular olives has a market price of $30. The grower has determined that because of uncertain demand, no more than 40 barrels of pruned olives should be produced. Use LP to find the combination of barrels of pruned and regular olives that will yield the maximum possible profit. Also, how many acres should the olive grower devote to each growing process?

2-34 The stock brokerage firm of Blank, Leibowitz, and Weinberger has analyzed and recommended two stocks to an investors' club of college professors. The professors were interested in factors such as short-term growth, intermediate growth, and dividend rates. These data on each stock are as follows:

	Stock ($)	
Factor	Louisiana Gas and Power	Trimex Insulation
Short-term growth per $ invested	0.36	0.24
Intermediate growth per $ invested	1.67	1.50
Dividend rate	4%	8%

Each member of the club has the following investment requirements: (1) a growth of at least $875 in the short term, (2) a growth of at least $5,000 in the intermediate term, and (3) a dividend income of at least $200 per year. What is the smallest investment that a professor can make to meet these requirements?

2-35 *Serendipity*

The three princes of Serendip
Went on a little trip.
They could not carry too much weight:
More than three hundred pounds made them hesitate.
They planned to the ounce. When they returned to Ceylon
They discovered that their supplies were just about gone
When, what to their joy, Prince William found
A pile of coconuts on the ground.
"Each will bring sixty rupees," said Prince Richard with a grin
As he almost tripped over a lion skin.
"Look out!" cried Prince Robert with glee
As he spied some more lion skins under a tree.
"These are worth even more—three hundred rupees each
If we can just carry them all down to the beach."
Each skin weighed fifteen pounds and each coconut, five,
But they carried them all and made it alive.
The boat back to the island was very small
Fifteen cubic feet baggage capacity—that was all.
Each lion skin took up 1 cubic foot
While 8 coconuts the same space took.
With everything stowed, they headed to sea
And on the way calculated what their new wealth might be.
"Eureka!" cried Prince Robert, "Our worth is so great
That there's no other way we could return in this state.
Any other skins or nuts that we might have brought
Would now have us poorer. And now I know what—
I'll write my friend Horace in England, for surely
Only he can appreciate our serendipity."

Formulate and solve Serendipity to calculate "what their new wealth might be."

(The word *serendipity* was coined by the English writer Horace Walpole after a fairy tale titled *The Three Princes of Serendip.* The source of the problem is unknown.)

2-36 Androgynous Bicycle Company (ABC) has the hottest new products on the upscale toy market—boys' and girls' bikes in bright fashion colors, with oversized hubs and axles; shell-design safety tires; strong padded frames; chrome-plated chains, brackets, and valves; and nonslip handlebars. ABC can sell its bicycles at the following prices: boys' bikes—$225, girls' bikes—$175. Although the demand for boys' bikes is stronger, ABC wants to make sure that both genders are well served. The firm would therefore like to ensure that the number of girls' bikes made is at least 30% of the total production.

The firm's accountant has determined that direct labor costs will be 45% of the price ABC receives for the boys' model and 40% of the price received for the girls' model. Production costs other than labor, but excluding painting and packaging, are $38.75 per boys' bicycle and $30 per girls' bicycle. Painting and packaging are $20 per bike, regardless of model.

The Orlando plant's overall production capacity is 390 bicycles per day. Each boys' bike requires 3.2 labor hours to complete and each girls' model, 2.4 hours. ABC currently employs 140 workers, who each put in an 8-hour day. The firm has no desire to hire or fire to affect labor availability, for it believes its stable workforce is one of its biggest assets.

(a) Determine the best product mix for ABC.
(b) What is the best product mix if ABC is willing to withdraw the 30% requirement for girls' bikes?

2-37 Modem Corporation of America (MCA) is the world's largest producer of high-speed communication devices for microcomputers. MCA sold 9,000 of the regular model and 10,400 of the intelligent model this September. Its income statement for the month is shown in Table 2.3. Costs presented are typical of prior months and are expected to remain at the same levels in the near future.

The firm is facing several constraints as it prepares its November production plan. First, it has experienced a tremendous demand and has been unable to keep any significant inventory in stock. This situation is not expected to change. Second, the firm is located in a small Iowa town from which additional labor is not readily available. Workers can be shifted from production of one model to another, however. To produce the 9,000 regular models in September required 5,000 direct labor hours, while the 10,400 intelligent models required 10,400 direct labor hours. Third, MCA is experiencing a problem affecting the intelligent model, each of which requires one unit of a specially made microprocessor. The lone supplier for this component is unreliable, and MCA believes he will supply no more than 8,000 microprocessors in November. Nevertheless, because the intelligent model is a model that MCA cannot afford to ignore, the firm would like to ensure that this model constitutes at least 25% of the total production. What is the optimal product mix of the two models that will allow MCA to maximize profits in November?

2-38 Ana's Cafe does a large lunchtime carry-out business. The cafe offers two burrito specials: Mild and Spicy. The profit on one serving of Mild is $0.58, while the profit on one serving of Spicy is $0.45. Each serving of Mild requires 0.15 pounds of beef, 0.36 cups of beans, and 3 ounces of Ana's homemade salsa. Each serving of Spicy requires 0.30 pounds of beef, 0.40 cups of beans, 2 ounces of Ana's homemade salsa, and

TABLE 2.3

Table for Problem 2-37: MCA Income Statement

	REGULAR MODEMS	INTELLIGENT MODEMS
Sales	$450,000	$640,000
Less: Discounts	10,000	15,000
Returns	12,000	9,500
Warranty replacements	4,000	2,500
Net sales	$424,000	$613,000
Sales costs		
Direct labor	60,000	76,800
Indirect labor	9,000	11,520
Materials cost	90,000	128,000
Depreciation	40,000	50,800
Cost of sales	$199,000	$267,120
Gross profit	$225,000	$345,880
Selling and general expenses		
General expenses—variable	30,000	35,000
General expenses—fixed	36,000	40,000
Advertising	28,000	25,000
Sales commissions	31,000	60,000
Total operating cost	$125,000	$160,000
Pretax income	$100,000	$185,880
Income taxes (25%)	25,000	46,470
Net income	$ 75,000	$139,410

5 ounces of her special hot sauce. Today, Ana has 8.5 pounds of beef, 13 cups of beans, 95 ounces of homemade salsa, and 125 ounces of hot sauce available. Demand is unlimited. What should Ana do today?

Note: Problems 2-39 to 2-45 are straightforward extensions of the two-variable problems we have seen so far and involve more than two variables. They therefore cannot be solved graphically. They are intended to give you an excellent opportunity to get familiar with formulating larger LP problems and solving them using Excel.

2-39 The Laser Printer Company decides monthly what to produce during the subsequent month. It produces three types of specialty printers—the Laser Rocket, the Laser Omega, and the Laser Alpha—which bring them profits of $60, $90, and $73, respectively. The Laser Rocket requires 2.9 hours of assembly time and 1.4 hours of testing time. The Laser Omega requires 3.7 hours of assembly time and 2.1 hours of testing time. The Laser Alpha requires 3 hours of assembly time and 1.7 hours of testing time. The company wants to ensure that the Laser Omega constitutes at least 15% of the total production and that the Laser Omega and Laser Rocket together constitute at least 40% of the total production. There are 4,000 hours of assembly time and 2,000 hours of testing time available for the month. What combination of printers should Laser produce to maximize profits?

2-40 The Feed 'n' Ship Ranch fattens cattle for local farmers and ships them to meat markets in Kansas City and Omaha. The owners of the ranch seek to determine the amounts of cattle feed to buy so that minimum nutritional standards are satisfied and at the same time total feed costs are minimized. The feed mix used can be made up of three grains that contain the following nutrients per pound of feed:

	Nutrient (Ounces per Pound of Feed)			
Feed	A	B	C	D
Stock X	3	2	1	6
Stock Y	2	3	0	8
Stock Z	4	1	2	4

The cost per pound of stocks X, Y, and Z are $3, $4, and $2.25, respectively. The minimum requirement per animal per month is 4 pounds of nutrient A, 5 pounds of nutrient B, 1 pound of nutrient C, and 8 pounds of nutrient D.

The ranch faces one additional restriction: It can obtain only 500 pounds of stock Z per month from the feed supplier, regardless of its need. Because there are usually 100 cattle at the Feed 'n' Ship Ranch at any given time, this means that no more than 5 pounds of stock Z can be counted on for use in the feed of each animal per month. Formulate this problem as a linear program and solve it by using Excel.

2-41 The Weinberger Electronics Corporation manufactures four highly technical products that it supplies to aerospace firms that hold NASA contracts. Each of the products must pass through the following departments before they are shipped: wiring, drilling, assembly, and inspection. The time requirement (in hours) for each unit produced, the available time in each department each month, minimum production levels for each product, and unit profits for each product are summarized in the following table:

	Department				Unit	Minimum
Product	Wiring	Drilling	Assembly	Inspection	Profit	Needed
XJ201	0.5	0.3	0.2	0.5	$ 9	150
XM897	1.5	1.0	4.0	1.0	$12	100
TR29	1.5	2.0	1.0	0.5	$15	300
BR788	1.0	3.0	2.0	0.5	$11	400
Capacity (Hours)	15,000	17,000	10,000	12,000		

The production manager has the responsibility of specifying production levels for each product for the coming month. Help him by formulating the problem and solving it by using Excel.

2-42 XRP Industries produces high-quality aluminum valves for production machinery. The production department is considering the schedule for the next month. Each valve must go through three separate machines during the fabrication process. After fabrication, each valve is inspected by a human being, who spends 15 minutes per valve. There are 525 inspection hours available for the month. The time required (in hours) by each machine to work on each valve is shown in the following table. Also shown are the minimum number of valves that must be produced for the month and the unit profit for each valve:

	Department			Unit	Minimum
Product	Drilling	Milling	Lathe	Profit	Needed
X4509	0.40	0.60	1.20	$16	200
X3125	0.30	0.65	0.60	$12	250
X4950	0.45	0.52	0.50	$13	600
X2173	0.35	0.48	0.70	$ 8	450
Capacity (Hours)	700	890	1,200		

Determine the optimal production mix for XRP Industries to make the best use of its profit potential.

2-43 The Canal Street Party Mix Company (CSPM) packages and sells three different one-pound canned party mixes: Plain Nuts, Mixed Nuts, and Premium Mix. Plain Nuts sells for $2.25 per can, Mixed Nuts sells for $3.37, and Premium Nuts sells for $6.49 per can. A can of Plain Nuts contains 0.8 pound peanuts and 0.2 pound cashews. A can of Mixed Nuts consists of 0.5 pound

peanuts, 0.3 pound cashews, 0.1 pound almonds, and 0.1 pound walnuts. A can of Premium Nuts is made up of 0.3 pound cashews, 0.4 pound almonds, and 0.4 pound walnuts. CSPM has on hand 500 pounds of peanuts, 225 pounds of cashews, 100 pounds of almonds, and 80 pounds of walnuts. Past demand indicates that customers purchase at least twice as many cans of Plain Nuts as Premium Nuts. What should CSPM do if it would like to produce the different products in a way that will maximize total revenue?

2-44 An investor is considering three different railroad stocks to complement his portfolio: B & O Railroad, Short Line Railroad, and Reading Railroad. His broker has given him the following information:

	Stock ($)		
Factor	B & O	Short Line	Reading
Short-term growth per $ invested	0.39	0.26	0.42
Intermediate growth per $ invested	1.59	1.70	1.45
Dividend rate	8%	4%	6%

The investor's criteria are as follows: (1) Investments should yield short-term growth of at least $1,000, (2) investments should yield intermediate-term growth of at least $6,000, and (3) dividends should be at least $250 per year. Determine the least amount the investor can invest and how that investment should be allocated among the three stocks.

2-45 The architect in Problem 2-23 has been informed that the bank would like to add a mini-size box, which will rent for $17 per year and will consume 43.2 square inches of wall space. The bank has now asked for at least 350 total boxes, of which at least 80 boxes should be large and 100 boxes should be mini. However, it wants the total area occupied by large and mini boxes to be at most 50% of the available space. How many boxes of each type should the architect now include in order to maximize revenue? Is the addition of mini boxes beneficial to the bank?

CASE STUDY

Mexicana Wire Winding, Inc.

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

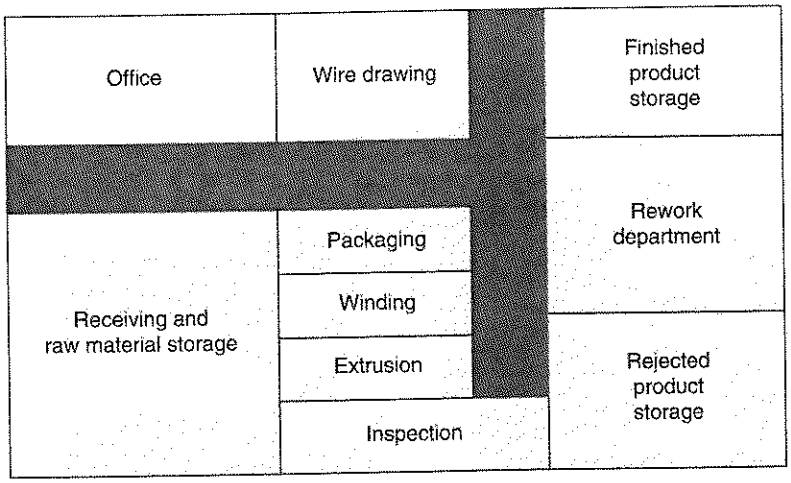
April Orders

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 Mexicana will manufacture 600 units of product W0007X and 150 units of product W0075C for him during April.

FIGURE 2.16

Mexicana Wire Winding Inc.



Standard Cost

PRODUCT	MATERIAL	LABOR	OVERHEAD	SELLING PRICE
W0075C	$33.00	$ 9.90	$23.10	$100.00
W00033C	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

Selecting Operating Data

Average output per month = 2,400 units

Average machine utilization = 63%

Average percentage of production sent 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: Employees 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 Excel printouts included.
2. Discuss the need for temporary workers in the drawing department.
3. Discuss the plant layout.

CASE STUDY

Golding Landscaping and Plants, Inc.

Kenneth and Patricia Golding spent a career as a husband-and-wife real estate investment partnership in Washington, DC. When they finally retired to a 25-acre farm in northern Virginia's Fairfax County, they became ardent amateur gardeners. Kenneth planted shrubs and fruit trees, and Patricia spent her hours potting all sizes of plants. When the volume of shrubs and plants reached the point that the Goldings began to think of their hobby in a serious vein, they built a greenhouse adjacent to their home and installed heating and watering systems.

By 2005, the Goldings realized that their retirement from real estate had really only led to a second career—in the plant and shrub business—and they filed for a Virginia business license. Within a matter of months, they asked their attorney to file incorporation documents and formed the firm Golding Landscaping and Plants, Inc.

Early in the new business's existence, Kenneth Golding recognized the need for a high-quality commercial fertilizer that he could blend himself, both for sale and for his own nursery. His goal was to keep his costs to a minimum while producing a top-notch product that was especially suited to the northern Virginia climate.

Working with chemists at George Mason University, Golding blended "Golding-Grow." It consists of four chemical compounds: C-30, C-92, D-21, and E-11. The cost per pound for each compound is indicated in the following table:

CHEMICAL COMPOUND	COST PER POUND
C-30	0.12
C-92	0.09
D-21	0.11
E-11	0.04

The specifications for Golding-Grow are as follows:

a. Chemical E-11 must comprise at least 15% of the blend.

b. C-92 and C-30 must together constitute at least 45% of the blend.

c. D-21 and C-92 can together constitute no more than 30% of the blend.

d. Golding-Grow is packaged and sold in 50-pound bags.

Discussion Questions

1. 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.
2. Solve using Excel to find the best solution.

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INTERNET CASE STUDY

See our Internet home page at www. prenhall.com/balakrishnan for this additional case study: Agri Chem Corporation.

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