**EXERCISES**

6.11. Production Planning for Components Rummel Electronics produces two PC cards, a modem and a network adapter. Demand for these two products exceeds the amount that the firm can make, but there are no plans to increase production capacity in the short run. Instead, the firm plans to use subcontracting.

The two main stages of production are fabrication and assembly, and either step can be subcontracted for either type of card. However, the company policy is not to subcontract both steps for either product. (That is, if modem cards are fabricated by a subcontractor, then they must be assembled in-house.) Components made by subcontractors must pass through the shipping and receiving departments, just like components made internally. At present, the firm has 5200 hours available in fabrication, 3600 in assembly and 3200 in shipping/inspection. The production requirements, in hours per unit, are given in the following table.

|  |  |  |  |
| --- | --- | --- | --- |
| Product/mode | Fab. | Ass. | Ship. |
| Modem, made entirely in-house | 0.35 | 0.16 | 0.08 |
| Network, made entirely in-house | 0.47 | 0.15 | 0.12 |
| Modem, fabricated by subcontractor | – | 0.18 | 0.10 |
| Network, fabricated by subcontractor | – | 0.16 | 0.15 |
| Modem, assembled by subcontractor | 0.35 | – | 0.09 |
| Network, assembled by subcontractor | 0.47 | – | 0.14 |

The direct material costs for the modem cards are $3.25 for manufacturing and $0.50 for assembly; for network cards, the costs are $6.10 and $0.50. Subcontracting the manufacturing operation costs $5.35 for modem cards and $8.50 for network cards. Subcontracting the assembly operation costs $1.50 for either product. Modem cards sell for $20, and network cards sell for $28. The firm’s policy, for each product, is that at most 40 percent of the units produced can have subcontracted fabrication, and at most 70 percent of the units can have subcontracted assembly.

* + - 1. Determine the production and subcontracting schedule that will maximize profits, given that Rummel Electronics wishes its schedule to contain an integer number of units produced and subcontracted.
      2. Solve the problem without the integer restrictions. What is the solution? By how much (in percentage terms) do the restrictions alter the value of the optimal objective function?

**6.12. Training the Staff** Fylstra Software Systems (FSS) has embarked on a new strategy that will provide technical support to all users from its small call center. For this purpose, FSS will train several agents, first to become superficially familiar with its software product and then to develop deep expertise in one or more of the four key areas: Optimization, Simulation, Sensitivity Analyses, and Data Mining. Agents will be paid according to the nature of their expertise. Agents with one area of expertise will be paid $100/hour; agents with two areas will be paid $125/hour; agents with three areas will be paid $140/hour; and agents with four areas will be paid $150/hour. (Unfortunately, no one will have obtained four areas of expertise by the time the call center goes on line.)

FSS has decided that it will need at least 12 agents with expertise in Optimization, 7 in Simulation, 5 in Sensitivity Analyses, and 6 in Data Mining.

1. What is the minimum hourly operating cost for the call center, at the level that satisfies the predicted requirements at FSS?
2. As time goes by, FSS plans to offer its agents training in each of key areas. Ultimately, FSS would like at least 40% of the call center workforce to have expertise in all four areas. How much can the cost in (a) be reduced once there has been time to train agents in all four areas of expertise?

6.13. Catering Logistics Jessica’s Catering Service bakes and delivers lasagnas to parties and group meetings. In a typical week, Jessica has around 40 orders. Each order involves a specific amount of the required lasagna in pounds. A small group would need about 20 pounds, whereas a large group would need almost triple that amount. The following table shows the different customer orders that have come in this week, grouped into eight categories by weight.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Job type | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Weight (pounds) | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 |
| Number | 10 | 5 | 4 | 7 | 3 | 9 | 2 | 1 |

1. Jessica has an inventory of 100 six-pound trays and 80 ten-pound trays. Although she appears to have enough capacity in her trays, she would like to plan her orders so that the amount of excess lasagna is kept to a minimum.
2. How many six-pound trays and ten-pound trays should Jessica use for each of the orders?

6.14. Shipping Carpets A manufacturer of nylon carpets produces rolls of carpeting at four factories and ships them to distributors in five locations. The table below shows the capacities at the factories and the demands at the distributors for the next quarter, all given in thousands of rolls. Also shown are the unit transportation costs between each factory and each distributor, stated in cost per roll.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | D1 | D2 | D3 | D4 | D5 | *Capacity* |
| F1 | 11 | 16 | 18 | 22 | 15 | 42 |
| F2 | 12 | 24 | 20 | 21 | 18 | 71 |
| F3 | 18 | 17 | 15 | 15 | 20 | 59 |
| F4 | 17 | 22 | 14 | 24 | 21 | 52 |
| *Demand* | 41 | 56 | 29 | 31 | 50 |  |

1. If the manufacturer wishes to meet the demand at the minimum total transportation cost, what is the optimal distribution plan and its cost?
2. Suppose that the manufacturer's policy is that each distributor must be supplied from a single factory. What is the optimal distribution plan under this policy?
3. By how much (in percentage terms) does the single-factory policy inflate distribution cost?

6.15. **Locating ATMs** The Fellsway Bank is considering placing ATM machines in the town centers of some of the following six communities: Arlington, Belmont, Cambridge, Winchester, Stoneham, and Melrose. The bank would like to purchase the minimum number of ATM machines needed to ensure that at least one ATM location is within a ten-minute drive from the center of each of these six communities. The times required to drive between the communities are shown in the table below.

#### *Driving times (in minutes) between the centers of six communities*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| *Town* | *Arlington* | *Belmont* | *Cambridge* | *Winchester* | *Stoneham* | *Melrose* |
| Arlington | 0 | 5 | 10 | 15 | 20 | 15 |
| Belmont | 5 | 0 | 8 | 10 | 15 | 12 |
| Cambridge | 10 | 8 | 0 | 15 | 20 | 10 |
| Winchester | 15 | 10 | 15 | 0 | 10 | 12 |
| Stoneham | 20 | 15 | 20 | 10 | 0 | 12 |
| Melrose | 15 | 12 | 10 | 12 | 12 | 0 |

1. What is the optimal number of ATM locations for the bank to select?
2. Revisit the model and vary the driving time floor from 5 minutes to 20 minutes and construct a chart to display the optimal number of ATMs in each case.

6.16. Locating Services The Division of Motor Vehicles (DMV) in Wyoming operates several offices around the state. Citizens must travel to one of these offices to register a car, obtain a title, renew an operator’s license, and perform a number of other minor activities. However, it is expensive for the DMV to operate a large number of offices, so the DMV has been keeping some offices open only three days per week and closing down other offices entirely in an attempt to reduce expenses. Recently, the suggestion was made to have one mobile DMV office which would operate out of a trailer and appear in a different location each day. The question then became: How much coverage could the mobile design provide? A possible standard was proposed: Locate the mobile office so that at least once a week, residents of the state could go to the DMV in their own county, or in a neighboring county.[[1]](#footnote-1)

Is it possible to locate the mobile office in such a way that for any county, the office will either locate in that county or locate in a neighboring county at least once per (5-day) week? If so, which counties should host the office for a day? If not, what is the minimum number of days required to provide all residents access within their county or a neighboring county?

**6.17. Asset Sales** Oxbridge College bought several properties during the real estate boom but has decided to sell them off in the next five years to produce sorely needed operating funds. An independent appraiser has estimated the potential sales value (in thousands of dollars) for each property in each of the five years, accounting for anticipated appreciation, as summarized in the table below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
| Apartment 1 | 685 | 691 | 696 | 700 | 706 |
| Office 1 | 584 | 588 | 593 | 598 | 604 |
| Motel 1 | 201 | 206 | 213 | 220 | 226 |
| Office 2 | 410 | 415 | 421 | 425 | 429 |
| Motel 2 | 472 | 478 | 484 | 489 | 495 |
| Apartment 2 | 780 | 786 | 791 | 798 | 804 |
| Office 3 | 472 | 478 | 482 | 488 | 494 |

From these sales, Oxbridge needs to raise at least $500,000 this year toward its operating budget. This requirement is expected to grow at the rate of 10% per year in future years. What is the maximum value it can obtain from these properties over the five-year horizon?

6.18. Scheduling Reservations Reed’s Rent-a-Car is a traditional auto rental company facing the problem of assigning vehicles to weekend demands. However, Reed’s distinguishes rentals by car type. Its fleet consists of three compact (C) cars, five mid-size (M) cars and three full-size (F) cars. The customer demands that have been logged in are listed below.

|  |  |  |  |
| --- | --- | --- | --- |
| Days | C | M | F |
| Fri–Mon | 0 | 1 | 0 |
| Fri–Sat | 1 | 2 | 1 |
| Fri–Sun | 2 | 2 | 1 |
| Sat–Sun | 1 | 3 | 0 |
| Sat–Mon | 3 | 0 | 0 |
| Sun–Sun | 0 | 1 | 1 |

The rental rates depend on how many days the contract covers. Prices for compact cars are shown below. Mid-size cars carry a 10 percent premium, and full-size cars carry a 20 percent premium.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Days | 1 | 2 | 3 | 4 |
| Rate | 39.95 | 74.95 | 99.95 | 119.95 |

Assume Reed’s were to prohibit a customer who ordered one size from renting another size. What is the maximum revenue that can be generated from the list of orders?

Assume Reed’s were to permit a customer to substitute a larger size for any order, but with no change in price. What is the maximum revenue that can be generated from the list of orders?

In the optimal solution of (b), what percentage of dollar demand is satisfied?

6.19. Cutting Stock Poly Products sells packaging tape to industrial customers. All tape is sold in 100-foot rolls that are cut in various widths from a master roll, which is 15 inches wide. The product line consists of the following widths: 2″, 3″, 5″, 7″, and 11″. These can be cut in different combinations from a 15-inch master roll. For example, one combination might consist of three cuts of 5″ each. Another combination might consist of two 2″ cuts and an 11″ cut. Both of these combinations use the entire 15-inch roll without any waste, but other combinations are also possible. For example, another combination might consist of two 7″ cuts. This combination creates one inch of waste for every roll cut this way.

Each week, Poly Products collects demands from its customers and distributors and must figure out how to configure the cuts in its master rolls. To do so, the production manager lists all possible combinations of cuts and tries to fit them together so that waste is minimized while demand is met. (In particular, demand must be met exactly, because Poly Products does not keep inventories of its tape.) This week’s demands are shown below.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Size | 2″ | 3″ | 5″ | 7″ | 11″ |
| Demand | 20 | 30 | 40 | 50 | 60 |

1. How many combinations can be cut from a 15-inch master roll so that there is less than two inches of waste (i.e., the smallest quantity that can be sold) left on the roll?
2. Find a set of combinations that meets demand exactly and generates the minimum amount of waste. (Stated another way, the requirement is to meet or exceed demand for each size, but any excess must be counted as waste.) What is the optimal set of combinations and the minimum amount of waste?

**6.20. Allocating Storage** Mason Chemical Company is preparing to deliver volumes of three chemical products to a large customer. Chemicals A, B, and C have pending orders of 4700, 4100, and 3100 gallons, respectively. Mason has one large delivery truck available with nominally enough storage space to carry the required volume. However, the chemicals must not be mixed; they must be kept in segregated holding compartments. The truck's storage is partitioned into five storage areas which hold 2000, 2200, 2400, 2600, and 2800 gallons. Because of the segregation requirement, it may not be possible to deliver the full order, in which case Mason wants to deliver the largest possible volume. How should the five compartments be filled to optimize the delivery volume?

**6.21. Voting Methods** Three candidates, Adams, Buchanan, and Coolidge, are running for office. Anticipating that none of the three will gain a majority, election officials have asked voters to rank the candidates and are considering three methods for resolving the situation.

1. The candidate who receives the most first-place votes is the winner.
2. Each voter ranks the candidates, using a scale of 3 (first place), 2 (second place), and 1 (third place). The candidate with the highest average rank is the winner.
3. After the first round, eliminate the first-place votes of the candidate with the fewest first-place votes. For those ballots, award the second-place votes as if they were first-place votes. The candidate who receives the highest total of first-place votes is the winner.

It is possible to encounter a set of voter preferences under which each of the three schemes leads to a different winner. Find the smallest number of voters for which that outcome could occur.

1. A map of counties can be found by selecting a state at http://www.digital-topo-maps.com/county-map/ [↑](#footnote-ref-1)