Bus 190 sec 3

HW 3

c. Draw the profit line corresponding to a profit of $4000. Move the profit line as far from the origin as you can in order to determine which extreme point will provide the optimal solution. Compare your answer with the approach you used in part (b).
d. Which constraints are binding? Explain.
e. Suppose that the values of the objective function coefficients are $4 for each All-Pro model produced and $5 for each College model. Use the graphical solution procedure to determine the new optimal solution and the corresponding value of profit.

23. Embassy Motorcycles (EM) manufacturers two lightweight motorcycles designed for easy handling and safety. The EZ-Rider model has a new engine and a low profile that make it easy to balance. The Lady-Sport model is slightly larger, uses a more traditional engine, and is specifically designed to appeal to women riders. Embassy produces the engines for both models at its Des Moines, Iowa, plant. Each EZ-Rider engine requires 6 hours of manufacturing time and each Lady-Sport engine requires 3 hours of manufacturing time. The Des Moines plant has 2100 hours of engine manufacturing time available for the next production period. Embassy's motorcycle frame supplier can supply as many EZ-Rider frames as needed. However, the Lady-Sport frame is more complex and the supplier can only provide up to 280 Lady-Sport frames for the next production period. Final assembly and testing requires 2 hours for each EZ-Rider model and 2.5 hours for each Lady-Sport model. A maximum of 1000 hours of assembly and testing time are available for the next production period. The company's accounting department projects a profit contribution of $2400 for each EZ-Rider produced and $1800 for each Lady-Sport produced.
a. Formulate a linear programming model that can be used to determine the number of units of each model that should be produced in order to maximize the total contribution to profit.
b. Solve the problem graphically. What is the optimal solution?
c. Which constraints are binding?

SELF test

24. Kelson Sporting Equipment, Inc., makes two different types of baseball gloves: a regular model and a catcher's model. The firm has 900 hours of production time available in its cutting and sewing department, 300 hours available in its finishing department, and 100 hours available in its packaging and shipping department. The production time requirements and the profit contribution per glove are given in the following table:

	Production Time (hours)			
Model	**Cutting and Sewing**	**Finishing**	**Packaging and Shipping**	**Profit/Glove**
Regular model	1	$1/2$	$1/8$	$5
Catcher's model	$3/2$	$1/3$	$1/4$	$8

Assuming that the company is interested in maximizing the total profit contribution, answer the following:
a. What is the linear programming model for this problem?
b. Find the optimal solution using the graphical solution procedure. How many gloves of each model should Kelson manufacture?
c. What is the total profit contribution Kelson can earn with the given production quantities?
d. How many hours of production time will be scheduled in each department?
e. What is the slack time in each department?

25. George Johnson recently inherited a large sum of money; he wants to use a portion of this money to set up a trust fund for his two children. The trust fund has two investment options: (1) a bond fund and (2) a stock fund. The projected returns over the life of the investments are 6% for the bond fund and 10% for the stock fund. Whatever portion of the inheritance George finally decides to commit to the trust fund, he wants to invest at least 30% of that amount in the bond fund. In addition, he wants to select a mix that will enable him to obtain a total return of at least 7.5%.
    a. Formulate a linear programming model that can be used to determine the percentage that should be allocated to each of the possible investment alternatives.
    b. Solve the problem using the graphical solution procedure.

26. The Sea Wharf Restaurant would like to determine the best way to allocate a monthly advertising budget of $1000 between newspaper advertising and radio advertising. Management decided that at least 25% of the budget must be spent on each type of media, and that the amount of money spent on local newspaper advertising must be at least twice the amount spent on radio advertising. A marketing consultant developed an index that measures audience exposure per dollar of advertising on a scale from 0 to 100, with higher values implying greater audience exposure. If the value of the index for local newspaper advertising is 50 and the value of the index for spot radio advertising is 80, how should the restaurant allocate its advertising budget in order to maximize the value of total audience exposure?
    a. Formulate a linear programming model that can be used to determine how the restaurant should allocate its advertising budget in order to maximize the value of total audience exposure.
    b. Solve the problem using the graphical solution procedure.

27. Blair & Rosen, Inc. (B&R) is a brokerage firm that specializes in investment portfolios designed to meet the specific risk tolerances of its clients. A client who contacted B&R this past week has a maximum of $50,000 to invest. B&R's investment advisor decides to recommend a portfolio consisting of two investment funds: an Internet fund and a Blue Chip fund. The Internet fund has a projected annual return of 12%, while the Blue Chip fund has a projected annual return of 9%. The investment advisor requires that at most $35,000 of the client's funds should be invested in the Internet fund. B&R services include a risk rating for each investment alternative. The Internet fund, which is the more risky of the two investment alternatives, has a risk rating of 6 per thousand dollars invested. The Blue Chip fund has a risk rating of 4 per thousand dollars invested. For example, if $10,000 is invested in each of the two investment funds, B&R's risk rating for the portfolio would be $6(10) + 4(10) = 100$. Finally, B&R developed a questionnaire to measure each client's risk tolerance. Based on the responses, each client is classified as a conservative, moderate, or aggressive investor. Suppose that the questionnaire results classified the current client as a moderate investor. B&R recommends that a client who is a moderate investor limit his or her portfolio to a maximum risk rating of 240.
    a. What is the recommended investment portfolio for this client? What is the annual return for the portfolio?
    b. Suppose that a second client with $50,000 to invest has been classified as an aggressive investor. B&R recommends that the maximum portfolio risk rating for an aggressive investor is 320. What is the recommended investment portfolio for this aggressive investor? Discuss what happens to the portfolio under the aggressive investor strategy.
    c. Suppose that a third client with $50,000 to invest has been classified as a conservative investor. B&R recommends that the maximum portfolio risk rating for a conservative investor is 160. Develop the recommended investment portfolio for the conservative investor. Discuss the interpretation of the slack variable for the total investment fund constraint.

28. Tom's, Inc., produces various Mexican food products and sells them to Western Foods, a chain of grocery stores located in Texas and New Mexico. Tom's, Inc., makes two salsa products: Western Foods Salsa and Mexico City Salsa. Essentially, the two products have different blends of whole tomatoes, tomato sauce, and tomato paste. The Western Foods Salsa is a blend of 50% whole tomatoes, 30% tomato sauce, and 20% tomato paste. The Mexico City Salsa, which has a thicker and chunkier consistency, consists of 70% whole tomatoes, 10% tomato sauce, and 20% tomato paste. Each jar of salsa produced weighs 10 ounces. For the current production period, Tom's, Inc., can purchase up to 280 pounds of whole tomatoes, 130 pounds of tomato sauce, and 100 pounds of tomato paste; the price per pound for these ingredients is \$0.96, \$0.64, and \$0.56, respectively. The cost of the spices and the other ingredients is approximately \$0.10 per jar. Tom's, Inc., buys empty glass jars for \$0.02 each, and labeling and filling costs are estimated to be \$0.03 for each jar of salsa produced. Tom's contract with Western Foods results in sales revenue of \$1.64 for each jar of Western Foods Salsa and \$1.93 for each jar of Mexico City Salsa.
    a. Develop a linear programming model that will enable Tom's to determine the mix of salsa products that will maximize the total profit contribution.
    b. Find the optimal solution.

29. AutoIgnite produces electronic ignition systems for automobiles at a plant in Cleveland, Ohio. Each ignition system is assembled from two components produced at AutoIgnite's plants in Buffalo, New York, and Dayton, Ohio. The Buffalo plant can produce 2000 units of component 1, 1000 units of component 2, or any combination of the two components each day. For instance, 60% of Buffalo's production time could be used to produce component 1 and 40% of Buffalo's production time could be used to produce component 2; in this case, the Buffalo plant would be able to produce $0.6(2000) = 1200$ units of component 1 each day and $0.4(1000) = 400$ units of component 2 each day. The Dayton plant can produce 600 units of component 1, 1400 units of component 2, or any combination of the two components each day. At the end of each day, the component production at Buffalo and Dayton is sent to Cleveland for assembly of the ignition systems on the following workday.
    a. Formulate a linear programming model that can be used to develop a daily production schedule for the Buffalo and Dayton plants that will maximize daily production of ignition systems at Cleveland.
    b. Find the optimal solution.

30. A financial advisor at Diehl Investments identified two companies that are likely candidates for a takeover in the near future. Eastern Cable is a leading manufacturer of flexible cable systems used in the construction industry, and ComSwitch is a new firm specializing in digital switching systems. Eastern Cable is currently trading for \$40 per share, and ComSwitch is currently trading for \$25 per share. If the takeovers occur, the financial advisor estimates that the price of Eastern Cable will go to \$55 per share and ComSwitch will go to \$43 per share. At this point in time, the financial advisor has identified ComSwitch as the higher-risk alternative. Assume that a client indicated a willingness to invest a maximum of \$50,000 in the two companies. The client wants to invest at least \$15,000 in Eastern Cable and at least \$10,000 in ComSwitch. Because of the higher risk associated with ComSwitch, the financial advisor has recommended that at most \$25,000 should be invested in ComSwitch.
    a. Formulate a linear programming model that can be used to determine the number of shares of Eastern Cable and the number of shares of ComSwitch that will meet the investment constraints and maximize the total return for the investment.
    b. Graph the feasible region.
    c. Determine the coordinates of each extreme point.
    d. Find the optimal solution.

a. Write the problem in standard form.
b. Solve the problem using the graphical solution procedure.
c. What are the values of the slack and surplus variables?

36. As part of a quality improvement initiative, Consolidated Electronics employees complete a three-day training program on team building and a two-day training program on problem solving. The manager of quality improvement has requested that at least 8 training programs on team building and at least 10 training programs on problem solving be offered during the next six months. In addition, senior-level management has specified that at least 25 training programs must be offered during this period. Consolidated Electronics uses a consultant to teach the training programs. During the next quarter, the consultant has 84 days of training time available. Each training program on team building costs $10,000 and each training program on problem solving costs $8000.
a. Formulate a linear programming model that can be used to determine the number of training programs on team building and the number of training programs on problem solving that should be offered in order to minimize total cost.
b. Graph the feasible region.
c. Determine the coordinates of each extreme point.
d. Solve for the minimum-cost solution.

37. The New England Cheese Company produces two cheese spreads by blending mild cheddar cheese with extra sharp cheddar cheese. The cheese spreads are packaged in 12-ounce containers, which are then sold to distributors throughout the Northeast. The Regular blend contains 80% mild cheddar and 20% extra sharp, and the Zesty blend contains 60% mild cheddar and 40% extra sharp. This year, a local dairy cooperative offered to provide up to 8100 pounds of mild cheddar cheese for $1.20 per pound and up to 3000 pounds of extra sharp cheddar cheese for $1.40 per pound. The cost to blend and package the cheese spreads, excluding the cost of the cheese, is $0.20 per container. If each container of Regular is sold for $1.95 and each container of Zesty is sold for $2.20, how many containers of Regular and Zesty should New England Cheese produce?

38. Applied Technology, Inc. (ATI) produces bicycle frames using two fiberglass materials that improve the strength-to-weight ratio of the frames. The cost of the standard-grade material is $7.50 per yard and the cost of the professional-grade material is $9.00 per yard. The standard- and professional-grade materials contain different amounts of fiberglass, carbon fiber, and Kevlar, as shown in the following table:

	Standard Grade	Professional Grade
Fiberglass	84%	58%
Carbon fiber	10%	30%
Kevlar	6%	12%

ATI signed a contract with a bicycle manufacturer to produce a new frame with a carbon fiber content of at least 20% and a Kevlar content of not greater than 10%. To meet the required weight specification, a total of 30 yards of material must be used for each frame.
a. Formulate a linear program to determine the number of yards of each grade of fiberglass material that ATI should use in each frame in order to minimize total cost. Define the decision variables and indicate the purpose of each constraint.
b. Use the graphical solution procedure to determine the feasible region. What are the coordinates of the extreme points?
c. Compute the total cost at each extreme point. What is the optimal solution?

d. The distributor of the fiberglass material is currently overstocked with the professional-grade material. To reduce inventory, the distributor offered ATI the opportunity to purchase the professional-grade material for $8 per yard. Will the optimal solution change?

e. Suppose that the distributor further lowers the price of the professional-grade material to $7.40 per yard. Will the optimal solution change? What effect would an even lower price for the professional-grade material have on the optimal solution? Explain.

39. Innis Investments manages funds for a number of companies and wealthy clients. The investment strategy is tailored to each client's needs. For a new client, Innis has been authorized to invest up to $1.2 million in two investment funds: a stock fund and a money market fund. Each unit of the stock fund costs $50 and provides an annual rate of return of 10%; each unit of the money market fund costs $100 and provides an annual rate of return of 4%.

The client wants to minimize risk subject to the requirement that the annual income from the investment be at least $60,000. According to Innis's risk measurement system, each unit invested in the stock fund has a risk index of 8, and each unit invested in the money market fund has a risk index of 3; the higher risk index associated with the stock fund simply indicates that it is the riskier investment. Innis's client also specifies that at least $300,000 be invested in the money market fund.

a. Determine how many units of each fund Innis should purchase for the client to minimize the total risk index for the portfolio.

b. How much annual income will this investment strategy generate?

c. Suppose the client desires to maximize annual return. How should the funds be invested?

40. Eastern Chemicals produces two types of lubricating fluids used in industrial manufacturing. Both products cost Eastern Chemicals $1 per gallon to produce. Based on an analysis of current inventory levels and outstanding orders for the next month, Eastern Chemicals' management specified that at least 30 gallons of product 1 and at least 20 gallons of product 2 must be produced during the next two weeks. Management also stated that an existing inventory of highly perishable raw material required in the production of both fluids must be used within the next two weeks. The current inventory of the perishable raw material is 80 pounds. Although more of this raw material can be ordered if necessary, any of the current inventory that is not used within the next two weeks will spoil—hence, the management requirement that at least 80 pounds be used in the next two weeks. Furthermore, it is known that product 1 requires 1 pound of this perishable raw material per gallon and product 2 requires 2 pounds of the raw material per gallon. Because Eastern Chemicals' objective is to keep its production costs at the minimum possible level, the firm's management is looking for a minimum-cost production plan that uses all the 80 pounds of perishable raw material and provides at least 30 gallons of product 1 and at least 20 gallons of product 2. What is the minimum-cost solution?

41. Southern Oil Company produces two grades of gasoline: regular and premium. The profit contributions are $0.30 per gallon for regular gasoline and $0.50 per gallon for premium gasoline. Each gallon of regular gasoline contains 0.3 gallons of grade A crude oil and each gallon of premium gasoline contains 0.6 gallons of grade A crude oil. For the next production period, Southern has 18,000 gallons of grade A crude oil available. The refinery used to produce the gasolines has a production capacity of 50,000 gallons for the next production period. Southern Oil's distributors have indicated that demand for the premium gasoline for the next production period will be at most 20,000 gallons.

a. Formulate a linear programming model that can be used to determine the number of gallons of regular gasoline and the number of gallons of premium gasoline that should be produced in order to maximize total profit contribution.

of the space to the generic brands. How many square feet of space should the manager allocate to the national brands and the generic brands under the following circumstances?

a. The national brands are more profitable than the generic brands.
b. Both brands are equally profitable.
c. The generic brand is more profitable than the national brand.

47. Discuss what happens to the M&D Chemicals problem (see Section 7.5) if the cost per gallon for product A is increased to $3.00 per gallon. What would you recommend? Explain.

48. For the M&D Chemicals problem in Section 7.5, discuss the effect of management's requiring total production of 500 gallons for the two products. List two or three actions M&D should consider to correct the situation you encounter.

49. PharmaPlus operates a chain of 30 pharmacies. The pharmacies are staffed by licensed pharmacists and pharmacy technicians. The company currently employs 85 full-time-equivalent pharmacists (combination of full time and part time) and 175 full-time-equivalent technicians. Each spring management reviews current staffing levels and makes hiring plans for the year. A recent forecast of the prescription load for the next year shows that at least 250 full-time-equivalent employees (pharmacists and technicians) will be required to staff the pharmacies. The personnel department expects 10 pharmacists and 30 technicians to leave over the next year. To accommodate the expected attrition and prepare for future growth, management states that at least 15 new pharmacists must be hired. In addition, PharmaPlus's new service quality guidelines specify no more than two technicians per licensed pharmacist. The average salary for licensed pharmacists is $40 per hour and the average salary for technicians is $10 per hour.

a. Determine a minimum-cost staffing plan for PharmaPlus. How many pharmacists and technicians are needed?
b. Given current staffing levels and expected attrition, how many new hires (if any) must be made to reach the level recommended in part (a)? What will be the impact on the payroll?

50. Expedition Outfitters manufactures a variety of specialty clothing for hiking, skiing, and mountain climbing. The company has decided to begin production on two new parkas designed for use in extremely cold weather: the Mount Everest Parka and the Rocky Mountain Parka. Expedition's manufacturing plant has 120 hours of cutting time and 120 hours of sewing time available for producing these two parkas. Each Mount Everest Parka requires 30 minutes of cutting time and 45 minutes of sewing time, and each Rocky Mountain Parka requires 20 minutes of cutting time and 15 minutes of sewing time. The labor and material cost is $150 for each Mount Everest Parka and $50 for each Rocky Mountain Parka, and the retail prices through the firm's mail order catalog are $250 for the Mount Everest Parka and $200 for the Rocky Mountain Parka. Because management believes that the Mount Everest Parka is a unique coat that will enhance the image of the firm, management specified that at least 20% of the total production must consist of this model. Assuming that Expedition Outfitters can sell as many coats of each type as it can produce, how many units of each model should it manufacture to maximize the total profit contribution?

51. English Motors, Ltd. (EML), developed a new four-wheel-drive sport utility vehicle. As part of the marketing campaign, EML produced a digitally recorded sales presentation to send to both owners of current EML four-wheel-drive vehicles as well as to owners of four-wheel-drive sport utility vehicles offered by competitors; EML refers to these two target markets as the current customer market and the new customer market. Individuals who receive the new promotion will also receive a coupon for a test drive of the new EML model for one weekend. A key factor in the success of the new promotion is the response rate, the percentage of individuals who receive the new promotion and test drive the new

Jackson Hole to produce as many of the cases during the upcoming week as possible; it will pay $18 for each case Jackson Hole can deliver. However, next week is a regularly scheduled vacation period for most of Jackson Hole's production employees; during this time, annual maintenance is performed for all equipment in the plant. Because of the downtime for maintenance, the M-100 will be available for no more than 15 hours, and the M-200 will be available for no more than 10 hours. However, because of the high set-up cost involved with both machines, management requires that, if production is scheduled on either machine, the machine must be operated for at least 5 hours. The supplier of the chemical material used in the production process informed Jackson Hole that a maximum of 1000 pounds of the chemical material will be available for next week's production; the cost for this raw material is $6 per pound. In addition to the raw material cost, Jackson Hole estimates that the hourly costs of operating the M-100 and the M-200 are $50 and $75, respectively.

a. Formulate a linear programming model that can be used to maximize the contribution to profit.
b. Find the optimal solution.

55. Xpress Technologies offers complete web design, programming, implementation, and hosting services for customers. Xpress prices their services by the project and categorizes each customer request into one of three possible project categories: simple HTML design, requires Java/Flash coding, requires secure transaction capabilities. Xpress charges $3000 for each simple HTML design project, $5000 for each Java/Flash coding project, and $8000 for each project requiring secure transaction capabilities. Xpress has two types of employees that it assigns to these projects: graphic designers who make $32/hour and programmers who make $36/hour. The company currently has two graphic designers and four programmers; each employee can work up to a total of 40 hours per week. Xpress estimates that a simple HTML project will require 2 hours from the graphic designers and 4 hours from the programmers; projects requiring Java/Flash coding require 5 hours from the graphic designers and 6 hours from the programmers; projects requiring secure transaction capabilities require 7 hours from the graphic designers and 12 hours from the programmers. Xpress currently has requests for eight simple HTML projects, six Java/Flash projects, and seven projects requiring secure transaction capabilities.
    a. Develop a linear program that will help Xpress Technologies to choose which of the projects to accept for the coming week to maximize profits.
    b. Find the optimal solution.

Case Problem 1 Workload Balancing

Digital Imaging (DI) produces color printers for both the professional and consumer markets. The DI consumer division recently introduced two new color printers. The DI-910 model can produce a $4'' \times 6''$ borderless color print in approximately 37 seconds. The more sophisticated and faster DI-950 can even produce a $13'' \times 19''$ borderless color print. Financial projections show profit contributions of $42 for each DI-910 and $87 for each DI-950.

The printers are assembled, tested, and packaged at DI's plant located in New Bern, North Carolina. This plant is highly automated and uses two manufacturing lines to produce the printers. Line 1 performs the assembly operation with times of 3 minutes per DI-910 printer and 6 minutes per DI-950 printer. Line 2 performs both the testing and packaging operations. Times are 4 minutes per DI-910 printer and 2 minutes per DI-950 printer. The shorter time for the DI-950 printer is a result of its faster print speed. Both manufacturing lines are in operation one 8-hour shift per day.