Homework Assignment #5

Due Jul 24 at 11:59pm **Points** 20 **Questions** 9 **Available** after Jul 17 at 12am
Time Limit None **Allowed Attempts** 2

Instructions

- This homework assignment will evaluate your understanding of the concepts covered in Chapter 6.
- You will need to follow course material and be able to search online code-sharing platforms to complete assignments using R.
- There is no time limit.
- You have TWO attempts to work on this homework and the highest one will be kept.
- You will be able to see the correct answers only after the last attempt.

Take the Quiz Again

Attempt History

	Attempt	Time	Score
LATEST	Attempt 1	295 minutes	15.53 out of 20

Answers will be shown after your last attempt

Score for this attempt: **15.53** out of 20
Submitted Jul 22 at 5:49pm
This attempt took 295 minutes.

Question 1

2 / 2 pts

Hospital administrators must schedule nurses so that the hospital's patients are provided adequate care. At the same time, careful attention must be paid to keeping costs down. From historical records, administrators can project the minimum number of nurses required to be on hand for various times of day and days of the week. The objective is to find the minimum total number of nurses required to provide adequate care.

Nurses start work at the beginning of one of the four-hour shifts given below (except for shift 6) and work for 8 consecutive hours. Hence, possible start times are the start of shifts 1 through 5. Also, assume that the projected required number of nurses factors in time for each nurse to have a meal break.

Shift	Time	Minimum Number of Nurses Needed
1	12:00 A.M. - 4:00 A.M.	8
2	4:00 A.M. - 8:00 A.M.	22
3	8:00 A.M. - 12:00 P.M.	16
4	12:00 P.M. - 4:00 P.M.	8
5	4:00 P.M. - 8:00 P.M.	21
6	8:00 P.M. - 12:00 A.M.	15

Hint: Note that exceeding the minimum number of needed nurses in each shift is acceptable so long as the total number of nurses in overall shifts is minimized.

Question

Formulate and solve the nurse scheduling problem as an integer program for one day for the data given below. (Let x_t = number of nurses who start work at the beginning of shift t, t = 1, 2, 3, 4, 5.)

x_1 = 8

x_2 = 14

x_3 = 2

x_4 = 6

x_5 = 15

Answer 1:

8

Answer 2:

14

Answer 3:

2

Answer 4:

6

Answer 5:

15

Question 2

2 / 2 pts

Suppose a certain manufacturing company produces connecting rods for 4- and 6-cylinder automobile engines using the same production line. The cost required to set up the production line to produce the 4-cylinder connecting rods is $2,200, and the cost required to set up the production line for the 6-cylinder connecting rods is $3,700. Manufacturing costs are $15 for each 4-cylinder connecting rod and $19 for each 6-cylinder connecting rod. Hawkins makes a decision at the end of each week as to which product will be manufactured the following week. If a production changeover is necessary from one week to the next, the weekend is used to reconfigure the production line. Once the line has been set up, the weekly production capacities are 5,000 6-cylinder connecting rods and 7,000 4-cylinder connecting rods. Let

- x_4= the number of 4-cylinder connecting rods produced next week
- x_6= the number of 6-cylinder connecting rods produced next week
- s_4= 1 if the production line is set up to produce the 4-cylinder connecting rods; 0 if otherwise
- s_6= 1 if the production line is set up to produce the 6-cylinder connecting rods; 0 if otherwise

Question

(a) Using the decision variables x4 and s4, write a constraint that limits next week's production of the 4-cylinder connecting rods to either 0 or 7,000 units.

x4 ≤ 7,000 s4

(b) Using the decision variables x6 and s6, write a constraint that limits next week's production of the 6-cylinder connecting rods to either 0 or 5,000 units.

x6 ≤ 5,000 s6

(c) Write a third constraint that, taken with the constraints from parts (a) and (b), limits the production of connecting rods for next week.

$s_4 + s_6 =$ 1

(d) Write an objective function for minimizing the cost of production for next week.

Min 15 x4 + 19 x6 + 2,200 s4 + 3,700s_6

Answer 1:

x4

Answer 2:

s4

Answer 3:

x6

Answer 4:

s6

Answer 5:

1

Answer 6:

x4

Answer 7:

x6

Answer 8:

s4

Partial

Question 3

1.25 / 2 pts

Hart Manufacturing makes three products. Each product requires manufacturing operations in three departments: A, B, and C. The labor-hour requirements, by department, are as follows.

Department	Product 1	Product 2	Product 3
A	1.50	3.00	2.00
B	2.00	1.00	2.50
C	0.25	0.25	0.25

During the next production period, the labor hours available are 450 in Department A, 350 in Department B, and 50 in Department C. The profit contributions per unit are $25 for product 1, $27 for product 2, and $29 for product 3.

Question

(a) Formulate a linear programming model for maximizing total profit contribution.
(Let P_i = units of product *i* produced, for i = 1, 2, 3.)

Max 25 P_1 + 27 P_2 + 29 P_3

s.t.

1.50 P_1 + 3.00 P_2 + 2.00 P_3 ≤ 450

2.00 P_1 + 1.00 P_2 + 2.50 P_3 ≤ 350

0.25 P_1 + 0.25 P_2 + 0.25 P_3 ≤ 50

$P_1, P_2, P_3 \geq 0$

(b) Solve the linear program formulated in part (a). How much of each product should be produced, and what is the projected total profit contribution (in dollars)?

P_1 = 60

P_2 = 80

P_3 = 60

Profit Contribution = 5400

Answer 1:

25

Answer 2:

27

Answer 3:

29

Answer 4:

1.50

Answer 5:

3.00

Answer 6:

2.00

Answer 7:

2.00

Answer 8:

1.00

Answer 9:

2.50

Answer 10:

0.25

Answer 11:

0.25

Answer 12:

0.25

Answer 13:

60

Answer 14:

80

Answer 15:

60

Answer 16:

5400

Partial

Question 4

1.29 / 2 pts

Hart Manufacturing makes three products. Each product requires manufacturing operations in three departments: A, B, and C. The labor-hour requirements, by department, are as follows.

Department	Product 1	Product 2	Product 3
A	1.50	3.00	2.00
B	2.00	1.00	2.50
C	0.25	0.25	0.25

During the next production period, the labor hours available are 450 in Department A, 350 in Department B, and 50 in Department C. The profit contributions per unit are $25 for product 1, $27 for product 2, and $29 for product 3.

Question

(a) After evaluating the solution obtained in the previous question, one of the production supervisors noted that production setup costs had not been taken into account. She noted that setup costs are $400 for product 1, $590 for product 2, and $570 for product 3. If the solution developed in the previous question is to be used, what is the total profit contribution (in dollars) after taking into account the setup costs?

Total profit contribution = $ 3840

(b) Management realized that the optimal product mix, taking setup costs into account, might be different from the one recommended in the previous question. Formulate a mixed-integer linear program that takes setup costs into account. Management also stated that we should not consider making more than 145 units of product 1, 160 units of product 2, or 175 units of product 3.

(Let P_i = units of product *i* produced and y_i be the 0-1 variable that is one if any quantity of product *i* is produced and zero otherwise, for i = 1, 2, 3.)

What is the objective function of the mixed-integer linear program?

Max $25P_1 + 27P_2 + 29P_2 -$ 400 $y_1 -$ 590 $y_2 -$ 570 y_3

s.t.

$1.5P_1 + 3P_2 + 2P_3 \le 45$

$2P_1 + 1P_2 + 2.5P_3 \le 35$

$.25P_1 + .25P_2 + .25P_3 \le 50$

$P_1 -$ 145 $y_1 \le 0$

$P_2 -$ 160 $y_2 \le 0$

$P_3 -$ 175 $y_3 \le 0$

$P_1, P_2, P_3, \ge 0$; $y_1, y_2, y_3 = 0, 1$

(c) Solve the mixed-integer linear program formulated in part (b). How much of each product should be produced, and what is the projected total profit (in dollars) contribution?

$P_1 =$ 0

$P_2 =$ 77

$P_3 =$ 109

y_1 = 0

y_2 = 1

y_3 = 0

Projected Total Profit Contribution = 4650

Answer 1:

3840

Answer 2:

400

Answer 3:

590

Answer 4:

570

Answer 5:

145

Answer 6:

160

Answer 7:

175

Answer 8:

0

Answer 9:

77

Answer 10:

109

Answer 11:

0

Answer 12:

1

Answer 13:

0

Answer 14:

4650

Partial

Question 5

1.75 / 2 pts

Galaxy Cloud Services operates several data centers across the United States containing servers that store and process data on the Internet. Suppose that Galaxy Cloud Services currently has five outdated data centers: one each in Michigan, Ohio, and California and two in New York. Management is considering increasing the capacity of these data centers to keep up with increasing demand. Each data center contains servers that are dedicated to Secure data and to Super Secure data. The cost to update each data center and the resulting increase in server capacity for each type of server are as follows.

Data Center Number	Data Center	Cost ($ millions)	Secure Servers	Super Secure Servers
1	Michigan	3.5	40	80
2	New York 1	2.0	20	30
3	New York 2	3.5	80	40
4	Ohio	2.0	50	30
5	California	4.0	90	60

The projected needs are for a total increase in capacity of 90 Secure servers and 90 Super Secure servers. Management wants to determine which data center(s) to update to meet projected needs and, at the same time, minimize the total cost of the added capacity.

Question

Formulate a binary integer programming model that could be used to determine the optimal solution to the capacity increase question-facing management.

$\left(\text{Let } x_i = \begin{cases} 1 \text{ if data center } i \text{ is updated} \\ 0 \text{ otherwise} \end{cases} \text{ for } i = 1, 2, 3, 4, 5. \text{ Give your objective function in millions of dollars.}\right)$

Min [3.5] x_1 + [2.0] x_2 + $3.5x_3$ + $2.0x_4$ + $4.0x_5$

s.t.

40 x_1 + 20 x_2 + $80x_3$ + $50x_4$ + $90x_5$ ≥

90

80 x_1 + 30 x_2 + $40x_3$ + $30x_4$ + $60x_5$ ≥

90

x_1, x_2, x_3, x_4, x_5 = 0, 1

Answer 1:

3.5

Answer 2:

2.0

Answer 3:

40

Answer 4:

20

Answer 5:

90

Answer 6:

80

Answer 7:

30

Answer 8:

90

Question 6

2 / 2 pts

Galaxy Cloud Services operates several data centers across the United States containing servers that store and process data on the Internet. Suppose that Galaxy Cloud Services currently has five outdated data centers: one each in Michigan, Ohio, and California and two in New York. Management is considering increasing the capacity of these data centers to keep up with increasing demand. Each data center contains servers that are

dedicated to Secure data and to Super Secure data. The cost to update each data center and the resulting increase in server capacity for each type of server are as follows.

Data Center Number	Data Center	Cost ($ millions)	Secure Servers	Super Secure Servers
1	Michigan	3.5	40	80
2	New York 1	2.0	20	30
3	New York 2	3.5	80	40
4	Ohio	2.0	50	30
5	California	4.0	90	60

The projected needs are for a total increase in capacity of 90 Secure servers and 90 Super Secure servers. Management wants to determine which data center(s) to update to meet projected needs and, at the same time, minimize the total cost of the added capacity.

Question

Solve the model formulated in the previous question to provide a recommendation for management. Which data center(s) do you recommend Galaxy Cloud Services update? (Select all that apply.)

- [ ] California
- [x] Michigan
- [ ] New York 1
- [ ] New York 2
- [x] Ohio

Partial

Question 7

1.33 / 2 pts

STAR Co. provides paper to smaller companies with volumes that are not large enough to warrant dealing directly with the paper mill. STAR receives 100-foot-wide paper rolls from the mill and cuts the rolls into smaller rolls of widths 12, 15, and 30 feet. The demands for these widths vary from week to week. The following cutting patterns have been established.

Pattern Number	12-ft	15-ft	30-ft	Trim Loss (ft)
1	0	6	0	10
2	0	0	3	10
3	8	0	0	4
4	3	0	2	4
5	7	1	0	1

Trim loss is the leftover paper from a pattern (e.g., for pattern 4, 3(12) + 0(15) + 2(30) = 96 feet used results in 100 − 96 = 4 feet of trim loss). Orders in hand for the coming week are 5,660 12-foot rolls, 1,690 15-foot rolls, and 3,340 30-foot rolls. Any of the three types of rolls produced in excess of the orders in hand will be sold on the open market at the selling price. No inventory is held.

Part of the model is shown below:

Let P_i = number of rolls cut into pattern i, for i = 1, 2, 3, 4, 5.

$$\text{Min} \quad 10P_1 + 10P_2 + 4P_3 + 4P_4 + 1P_5$$

s.t.

$$0P_1 + 0P_2 + 8P_3 + 3P_4 + 7P_5 \geq 5{,}660 \quad \text{demand 12-foot rolls}$$
$$6P_1 + 0P_2 + 0P_3 + 0P_4 + 1P_5 \geq 1{,}690 \quad \text{demand 15-foot rolls}$$
$$0P_1 + 3P_2 + 0P_3 + 2P_4 + 0P_5 \geq 3{,}340 \quad \text{demand 30-foot rolls}$$

Question

(a) Solve the model formulated in the question. What is the minimal amount of trim loss (in ft)?

Minimal amount of trim loss = 8370 ft

(b) How many of each pattern should be used?

Pattern 1 0 rolls

Pattern 2 0 rolls

Pattern 3 0 rolls

Pattern 4 1670 rolls

Pattern 5 1690 rolls

(c) How many of each type of roll will be sold on the open market?

12-ft 11180 rolls

15-ft 0 rolls

30-ft 0 rolls

Answer 1:

8370

Answer 2:

0

Answer 3:

0

Answer 4:

0

Answer 5:

1670

Answer 6:

1690

Answer 7:

11180

Answer 8:

0

Answer 9:

0

Partial

Question 8

2 / 3 pts

Brooks Development Corporation (BDC) faces the following capital budgeting decision. Six real estate projects are available for investment. The net present value and expenditures required for each project (in millions of dollars) are as follows.

Project	1	2	3	4	5	6
Net Present Value ($ millions)	$17	$7	$15	$16	$22	$11
Expenditure Required ($ millions)	$94	$38	$85	$74	$118	$54

There are conditions that limit the investment alternatives:

- At least two of projects 1, 3, 5, and 6 must be undertaken.
- If either project 3 or 5 is undertaken, they must both be undertaken.
- Project 4 cannot be undertaken unless both projects 1 and 3 also are undertaken.

The budget for this investment period is $220 million.

Question

Formulate and solve a binary integer program that will enable BDC to find the projects to invest in to maximize net present value while satisfying all project restrictions and not exceeding the budget.

$$\left(\text{Let } x_i = \begin{cases} 1 \text{ if project } i \text{ is undertaken} \\ 0 \text{ otherwise} \end{cases} \text{ for } i = 1, 2, 3, 4, 5, 6. \text{ Give your objective function in millions of dollars.}\right)$$

(a) What is the optimal net present value (in millions of dollars)?

$ 37 million

(b) Which projects will be undertaken? (Enter your answer as a comma-separated list of numbers. Use 1 for project 1, 2 for project 2, 3 for project 3, 4 for project 4, 5 for project 5, and 6 for project 6.)

Projects 3,5

(c) How much of the budget is unused (in millions of dollars)?

$ 17 million

Answer 1:

37

Answer 2:

3,5

Answer 3:

17

Partial

Question 9

1.91 / 3 pts

John White is the program scheduling manager for the television channel CCFO. John would like to plan the schedule of television shows for next Wednesday evening.

The table below lists nine shows under consideration. John must select exactly five of these shows for the period from 8:00 p.m. to 10:30 p.m. next Wednesday evening. For each television show, the estimated advertising revenue (in $ millions) is provided. Furthermore, each show has been categorized into one or more of the categories "Public Interest," "Violent," "Comedy," and "Drama." In the following table, a 1 indicates that the show is in the corresponding category and a 0 indicates it is not.

Number	Show	Revenue ($ millions)	Public Interest	Violent	Comedy	Drama
1	Sam's Place	$11	0	0	1	1
2	Texas Oil	$12	0	1	0	1
3	Cincinnati Law	$8	1	0	0	1
4	Jarred	$7	0	1	0	1
5	Bob & Mary	$4	0	0	1	0
6	Chainsaw	$6	0	1	0	0
7	Loving Life	$8	1	0	0	1
8	Islanders	$10	0	0	1	0
9	Urban Sprawl	$9	1	0	0	0

John would like to determine a revenue-maximizing schedule of television shows for next Wednesday evening. However, he must be mindful of the following considerations:

- Consideration 1: Exactly 5 television shows must be selected.
- Consideration 2: The schedule must include at least as many shows that are categorized as public interest as shows that are categorized as violent.
- Consideration 3: If John schedules "Loving Life," then he must also schedule either "Jarred" or "Cincinnati Law" (or both).
- Consideration 4: John cannot schedule both "Loving Life" and "Urban Sprawl."
- Consideration 5: If John schedules more than one show in the "Violent" category, he will lose an estimated $4 million in advertising revenues from family-oriented sponsors.

Question

Formulate and solve a binary integer program that models the decisions John faces.

Let:

- x_i = 1 if show *i* is selected and 0 if not, where i = 1, 2, 3, 4, 5, 6, 7, 8, 9 where the number corresponds to the order of shows given in the spreadsheet (e.g., *i* = 3 = Cincinnati Law).
- y = 1 if two or more Violent show is selected, 0 if not.
- Give your objective function millions of dollars. For Consideration 5, use the smallest (in magnitude) possible integer coefficient for
  y.

x_1 = 3

x_2 = 1

x_3 = 0

x_4 = 0

x_5 = 0

x_6 = 0

x_7 = 0

x_8 = 0

x_9 = 1

y = 0

Optimal revenue = $ 53 million

Answer 1:

3

Answer 2:

1

Answer 3:

0

Answer 4:

0

Answer 5:

0

Answer 6:

0

Answer 7:

0

Answer 8:

0

Answer 9:

1

Answer 10:

0

Answer 11:

53

Quiz Score: **15.53** out of 20