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1. A brand manager for a certain company must determine how much time to allocate between radio and television advertising during the next month. Market research has provided estimates of the audience exposure for each minute of advertising in each medium, which it would like to maximize. Costs per minute of advertising are also known, and the manager has a limited budget of $20,000. The manager has decided that because television ads have been found to be much more effective than radio ads, at least 75% of the time should be allocated to television. Use the following data to complete parts a and b.

Type of Ad	Exposure/Minute	Cost/Minute
Radio	350	$400
TV	750	$1900

a. Identify the decision variables, objective function, and constraints in simple verbal expressions.

Identify the decision variables. Select all that apply.

- A. Time spent on radio ads
- B. Time spent on TV ads
- C. Cost
- D. Exposure

Identify the objective function in a simple verbal expression. Choose the correct answer below.

- A. Minimize cost by adding the total cost of radio ads to the total cost of TV ads.
- B. Maximize exposure by adding the exposure from radio ads to the exposure from TV ads.
- C. Maximize the number of ads by adding the number of radio ads to the number of TV ads.
- D. Minimize time spent by adding the time spent on radio ads to the time spent on TV ads.

Identify the constraints in simple verbal expressions. Select all that apply.

- A. The number of TV ads and radio ads cannot be negative.
- B. The limited budget must be greater than or equal to the average cost per minute of ads multiplied by the sum of the minutes spent on radio ads and the minutes spent on TV ads.
- C. The money spent on the radio ads plus the money spent on TV ads cannot be more than the limited budget.
- D. Time spent on TV ads must be at least 75% of the total time spent on ads.
- E. Time spent on TV ads must be at least 75% of the time spent on radio ads.

b. Mathematically formulate a linear optimization model.

(Type integers or decimals. Do not round. Do not include the $ symbol in your answers.)

(1) _____ = _____ Radio + _____ TV

(2) _____ _____ Radio + _____ TV ≤ 20,000

_____ Radio ≤ TV

(3) _____

(1) ○ Maximize ○ Minimize (1) (2) ○ Cost ○ Exposure (3) ○ Radio > 0 ○ Radio ≥ 0 ○ TV ≥ 0 ○ Radio > 0 and TV > 0 ○ TV > 0 ○ Radio ≥ 0 and TV ≥ 0

2. A certain company produces clothing, footwear, and accessories for dancing and gymnastics. They produce three models of pointe shoes used by ballerinas to balance on the tips of their toes. The shoes are produced from four materials: cardstock, satin, plain fabric, and leather. The number of square inches of each type of material used in each model of shoe, the amount of material available, and the profit/model are shown. Complete parts a and b.

Material	Model 1	Model 2	Model 3	Material Available
Cardstock	11	10	15	1,300
Satin	23	20	21	2,000
Plain Fabric	40	40	30	8,500
Leather	13	13	10	1,100
Profit per model	$52	$46	$42	

a. Identify the decision variables, objective function, and constraints in simple verbal expressions.

Identify the decision variables. Select all that apply.

- ☐ **A.** Profit
- ☐ **B.** Cost
- ☐ **C.** Number of model 2 shoes produced
- ☐ **D.** Material used
- ☐ **E.** Number of model 3 shoes produced
- ☐ **F.** Number of model 1 shoes produced

Identify the objective function in a simple verbal expression. Choose the correct answer below.

- ○ **A.** Minimize the material used by minimizing the sum of the materials used for each type of shoe multiplied by the amount of materials used for that type of shoe.
- ○ **B.** Maximize the number of shoes produced by maximizing the sum of the number of model 1 shoes plus the number of model 2 shoes plus the number of model 3 shoes.
- ○ **C.** Maximize the profit by maximizing the sum the profits from each type of shoe.
- ○ **D.** Minimize the cost by minimizing the sum of the profits for each type of shoe multiplied by the cost of the materials for that type of shoe.

Identify the constraints in simple verbal expressions. Select all that apply.

- ☐ **A.** For each of the three types of shoes, the number of shoes produced cannot be negative.
- ☐ **B.** The profit cannot be negative.
- ☐ **C.** For each of the four types of materials, the total number of shoes produced must be less than or equal to the amount of that material that is available.
- ☐ **D.** For each of the four types of materials, the total amount of that material used to produce all shoe types must be less than or equal to the amount of that material that is available.

b. Mathematically formulate a linear optimization model.

(Type integers or decimals. Do not round. Do not include the $ symbol in your answers.)

(1) _____ = _____ M_1 + _____ / M_2 + _____ M_3

(2) _____

_____ M_1 + _____ / M_2 + _____ $M_3 \le 1{,}300$

_____ M_1 + _____ / M_2 + _____ $M_3 \le 2{,}000$

_____ M_1 + _____ / M_2 + _____ $M_3 \le 8{,}500$

_____ M_1 + _____ / M_2 + _____ $M_3 \le 1{,}100$

M_1, M_2, M_3 (3) _____ 0

(1) ○ Minimize ○ Maximize

(2) ○ Profit ○ Cost ○ Material used ○ Number of shoes

(3) ○ ≠ ○ = ○ > ○ ≥

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3. Valencia Products makes automobile radar detectors and assembles two models: LaserStop and SpeedBuster. Both models use the same electronic components. After reviewing the components required and the profit for each model, the firm found the following linear optimization model for profit, where L is the number of LaserStop models produced and S is the number of SpeedBuster models produced. Implement the linear optimization model on a spreadsheet and use Solver to find an optimal solution. Interpret the optimal solution, identify the binding constraints, and verify the values of the slack variables.

Maximize Profit = 122 L + 135 S

18 L + 13 S ≤ 4000 (Availability of component A)

5 L + 9 S ≤ 3500 (Availability of component B)

L ≥ 0 and S ≥ 0

Implement the linear optimization model and find an optimal solution. Interpret the optimal solution.

The optimal solution is to produce _____ LaserStop models and _____ SpeedBuster models. This solution gives the (1) _____ possible profit, which is $_____.

(Type integers or decimals rounded to two decimal places as needed.)

Component A (2) _____ a binding constraint and it has _____ slack.

Component B (3) _____ a binding constraint and it has _____ slack.

(Type integers or decimals rounded to two decimal places as needed.)

(1) ○ maximum ○ minimum

(2) ○ is ○ is not

(3) ○ is ○ is not

4. Burger Office Equipment produces two types of desks, standard and deluxe. Deluxe desks have oak tops and more expensive hardware and require additional time for finishing and polishing. After reviewing the hardware and labor required, along with the profit for each model, Burger Office Equipment found the following linear optimization model for profit, where S is the number of standard desks produced and D is the number of deluxe desks produced. Implement the linear optimization model on a spreadsheet and use Solver to find an optimal solution. Interpret the optimal solution, identify the binding constraints, and verify the values of the slack variables.

$$\begin{aligned} \text{Maximize Profit} = {} & 240\,S + 360\,D \\ & 75\,S + 55\,D \le 6000 && \text{(Availability of pine)} \\ & 20\,D \le 700 && \text{(Availability of oak)} \\ & 10\,S + 19\,D \le 400 && \text{(Availability of labor)} \\ & S \ge 0 \text{ and } D \ge 0 \end{aligned}$$

Implement the linear optimization model and find an optimal solution. Interpret the optimal solution.

The optimal solution is to produce _____ standard desks and _____ deluxe desks. This solution gives the (1) _____ possible profit, which is $_____.
(Type integers or decimals rounded to two decimal places as needed.)

Availability of pine (2) _____ a binding constraint and it has _____ slack.

Availability of oak (3) _____ a binding constraint and it has _____ slack.

Availability of labor (4) _____ a binding constraint and it has _____ slack.
(Type integers or decimals rounded to two decimal places as needed.)

(1) ○ maximum ○ minimum
(2) ○ is not ○ is
(3) ○ is ○ is not
(4) ○ is ○ is not