Optimizing Business Decisions

A catering company provides services for up to two events a day only on weekdays. In each event, the company provides a meal for each one of the event's attendees. Each week, the catering company has a schedule of the upcoming week's events and must plan accordingly. In deciding how to purchase/cook the meals, the catering company can choose from the following three options:

1. Purchase meals from company A. Company A charges $4 per meal.
2. Purchase meals from company B. Company B charges $3 per meal Monday through Wednesday and $5 per meal on Thursday and Friday. In addition, company B cannot provide more than 50 meals per event.
3. Cook the meals at a cost of $2. Due to logistical constraints, the catering company cannot cook for more than 55 people per event and cannot cook for more than 100 people in one day.

The catering company receives $8 per meal served given that it was requested. If the catering company provides additional meals, it will not be compensated. In this problem, this should be modeled as a constraint in which the amount of meals purchased/cook does not exceed the demand.

The following is the upcoming week's schedule:

	Monday	Tuesday	Wednesday	Thursday	Friday
Day Event (Event 1)	20	60	200	70	80
Evening Event (Event 2)	150	30	0	25	250

Every cell represents the amount of attendees at the corresponding event. For example, there are two events on Monday. One has 20 attendees and the other has 150 attendees. On Wednesday, there is only one event.

The following is the cost in dollars of each option every day:

	Monday	Tuesday	Wednesday	Thursday	Friday
Company A	4	4	4	4	4
Company B	3	3	3	5	5
Self Cook	2	2	2	2	2

For example, Company B charges have $3 per meal on Wednesday and $5 per meal on Thursday.

The company's task is to decide how to provide the upcoming week's meals. The goal is to maximize the upcoming week's profit (revenue - cost). Assume that the company's costs include only the meals' preparation/purchase and its revenue is based only on the meals sold.

Define the following variables:

- x_ij (i=1,2, j=1,2...,5) The amount of meals purchased from company A for event i on day j.
- y_ij (i=1,2, j=1,2...,5) The amount of meals purchased from company B for event i on day j.
- z_ij (i=1,2, j=1,2...,5) The amount of meals cooked by the catering company for event i on day j.

You can solve this problem with the spreadsheet software of your choice: LibreOffice, Excel, Google Sheets with OpenSolver, or OpenOffice

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Problem 1 - Objective Function

0.0/4.0 points (graded)
Before you set up the optimization problem in your spreadsheet software (Excel or other), we will walk you through the formulation.

Note: The (c_ij*x_kj + c_ij*x_kj + ... + c_ij*x_kj) term is the SUMPRODUCT of the 1x5 cost block of the ith option and jth day and the 1x5 x variables of the kth event on day j.

For example, (c_11*x_11 + c_12*x_12 + ... + c_15*x_15) is the SUMPRODUCT of company A's cost per meal during the week and the amount purchased from company A for the morning events.

Which of the following is a correct expression for the catering company's revenue? Define this expression to be the revenue.

- (c_11*x_11 + c_12*x_12 + ... + c_15*x_15) + (c_11*y_11 + c_12*y_12 + ... + c_15*y_15) + (c_11*z_11 + c_12*z_12 + ... + c_15*z_15)
- 8*((x_11 + x_12 + ... + x_15 + x_21 + x_22 + ... x_25) + (y_11 + y_12 + ... + y_15 + y_21 + y_22 + ... y_25) + (z_11 + z_12 + ... + z_15 + z_21 + z_22 + ... z_25)) ✔
- 4*(x_11 + x_12 + ... + x_15 + x_21 + x_22 + ... x_25) + 3*(y_11 + y_12 + ... + y_15 + y_21 + y_22 + ... y_25) + 2* (z_11 + z_12 + ... + z_15 + z_21 + z_22 + ... z_25)
- 4*(x_11 + x_12 + ... + x_15 + x_21 + x_22 + ... x_25) + 3*(y_11 + y_12 + y_13 + y_21 + y_22 + y_23) + 5*(y_14 + y_15 + y_24 + y_25) + 2* (z_11 + z_12 + ... + z_15 + z_21 + z_22 + ... z_25)

Which of the following is a correct expression for the catering company's costs? Define this expression to be the cost.

- (c_11*x_11 + c_12*x_12 + ... + c_15*x_15) + (c_11*y_11 + c_12*y_12 + ... + c_15*y_15) + (c_11*z_11 + c_12*z_12 + ... + c_15*z_15)
- (c_31*z_11 + c_32*z_22 + ... + c_35*z_15) + (c_31*z_21 + c_32*y_22 + ... + c_35*z_25)
- (c_11*x_11 + c_12*x_12 + ... + c_15*x_15) + (c_11*y_11 + c_12*y_12 + ... + c_15*y_15) + (c_11*z_11 + c_12*z_12 + ... + c_15*z_15) + (c_11*x_21 + c_12*x_22 + ... + c_15*x_25) + (c_11*y_21 + c_12*y_22 + ... + c_15*y_25) + (c_11*z_21 + c_12*z_22 + ... + c_15*z_25)
- (c_11*x_11 + c_12*x_12 + ... + c_15*x_15) + (c_11*x_21 + c_12*x_22 + ... + c_15*x_25) + (c_21*y_11 + c_22*y_12 + ... + c_25*y_15) + (c_21*y_21 + c_22*y_22 + ... + c_25*y_25) +(c_31*z_11 + c_32*z_12 + ... + c_35*z_15) + (c_31*z_21 + c_32*z_22 + ... + c_35*z_25) ✔

Which of the following is a correct expression for the objective function?

- maximize cost - revenue
- maximize revenue - cost ✔
- minimize revenue + cost
- minimize revenue - cost

Under the assumption that there is a feasible solution, will the objective value of this function ever be negative?

- Yes, it is possible that that the cost will be higher than the revenue.
- No, regardless of the decisions taken by the model, the catering company profits from every individual meal. ✔
- There is not enough information.

Submit You have used 0 of 2 attempts

Answers are displayed within the problem

Problem 2.1: Constraints

0.0/4.0 points (graded)

Let's organize our constraints in the following list:

- Company B cannot provide more than 50 meals per event

- The catering company cannot cook more than 55 meals per event

- The catering company cannot cook more than 100 meals per day

- Each amount chosen to be purchased/cooked is nonnegative

- $x_{ij} + y_{ij} + z_{ij} = a_{ij}$ for every $i = 1,2$ and $j = 1,...5$ where a_{ij} is the demand for event i on day j

How many constraints does this list correspond to?

Answer: 65

Which of the following is the correct constraint for "Company B cannot provide more than 50 meals on Monday for the morning event"?

- x_11 is less than or equal to 50
- c_11 * y_11 is less than or equal to 50
- y_11 is less than or equal to 50 ✔
- y_11 is greater than or equal to 50

Which of the following is the correct constraint for "the catering company cannot cook more than 55 meals on Monday for the evening event"?

- z_11 + z_21 is less than or equal to 55
- z_21 + y_21 + x_21 is less than or equal to 55
- z_21 is less than or equal to 55 ✔
- z_21 is equal to 55

Which of the following is the correct constraint for "the catering company cannot cook more than 100 meals on Monday"?

- z_11 is less than or equal to 100
- z_11 + z_21 is less than or equal to 100 ✔
- z_21 + y_21 + x_21 is less than or equal to 100
- c_21 * x_21 + c_21 * y_21 + c_21 * z_21 is less than or equal to 100

Submit You have used 0 of 2 attempts

Answers are displayed within the problem

Problem 2.2: Constraints (cont'd)

0.0/3.0 points (graded)
Let's observe the last two constraints:

- Each amount chosen to be purchased/cooked is nonnegative

- x_ij + y_ij + z_ij = a_ij for every i = 1,2 and j = 1,...5 where a_ij is the demand for event i on day j

Why do we constrain the amounts being served to be nonnegative? Select the best explanation.

- No reason, this is a redundant constraint in the model
- By definition, these variables are nonnegative - it is not possible to cook or purchase negative numbers of meals ✔
- Because all variables should be nonnegative

Why do we constrain the sum of amounts being served at each event to be equal to the demand? Select the best explanation.

- ○ No reason, this is a redundant constraint in the model
- ○ Because all variable that are fractions need to sum up to one.
- ○ There will be no revenue for any meal served that was not requested. Therefore, the catering company must restrict itself to serve the exact amount requested. ✔

If we change the last constarint to be "less than or equal to the demand" instead of "equal to the demand", will this affect the optimal value of the model?

- ○ No, since the catering company profits from each unit of dish served, it will maximize the amount of dishes to always serve the amount requested. ✔
- ○ Yes, this will allow the catering company the option of not serving all of the meals requested.
- ○ There is not enough information.

Submit You have used 0 of 2 attempts

ℹ Answers are displayed within the problem

Problem 3 - Sanity Check

0.0/4.0 points (graded)

As you set up your model, it may be helpful to check that the output is what you expect before submitting your answers. Answer the following before setting up your model to check your understanding.

How many attendees (meals) are expected in the upcoming week?

Answer: 885

Ignoring the constraints, assume the catering company chooses to cook all of the meals for the upcoming week. What is the objective value in such a scenario? Denote this solution to be the cooking solution and the value to be the cooking value.

Answer: 5310

Returning to our original problem which includes all of the constraints formulated, is the cooking solution feasible?

- ○ Yes
- ○ No ✔
- ○ Not enough information

Assuming there exists a feasible solution to our original problem, will the optimal revenue be higher than that of the cooking value?

- Yes
- No ✔
- Not enough information

Submit You have used 0 of 2 attempts

Answers are displayed within the problem

Problem 4 - Solving the Model

0.0/4.0 points (graded)
Formulate the model in LibreOffice/Excel and solve.

What is the optimal objective value?

Answer: 4435

How many meals are being purchased from company B on Wednesday for the morning event?

Answer: 50

Out of all the meals being cooked on Friday, the catering company wants to cook the maximum amount of meals for the evening event. Note that the catering company is still contrained to 55 meals per event.

Given this preference and the optimal objective value, how many meals are being cooked by the catering company on Friday for the evening event?

Answer: 55

Submit You have used 0 of 5 attempts

Answers are displayed within the problem

Problem 5 - Sensitivity Analysis

0.0/4.0 points (graded)

Suppose the original price to cook a meal increases by $0.5.

How will this impact the amount of meals being cooked? Answer this without re-solving the model.

- ○ It will stay the same ✔
- ○ It will be lower
- ○ It could be either of the above

How will this impact the optimal objective value? Answer this without re-solving the model.

- ○ It will stay the same
- ○ It will be lower ✔
- ○ It could be either of the above

Suppose the orginal price to cook a meal increases by $1.

How will this impact the amount of meals being cooked? Answer this without re-solving the model.

- ○ It will stay the same
- ○ It will be lower
- ○ It could be either of the above ✔

Suppose that the morning event on Monday requests an additional five meals at the last minute such that these meals cannot be purchased and must be cooked. Is the new problem feasible?

- ○ Yes ✔
- ○ No
- ○ Not enough information

Submit You have used 0 of 2 attempts

Answers are displayed within the problem