Exercises - Section 1: Lecture 2 – Yes-No Decisions and Related Constraints - Questions

For each of the following situations, create binary variables to model the yes/no decisions, and use those binary variables to model the specified expressions (you might also need to define some notation for data).

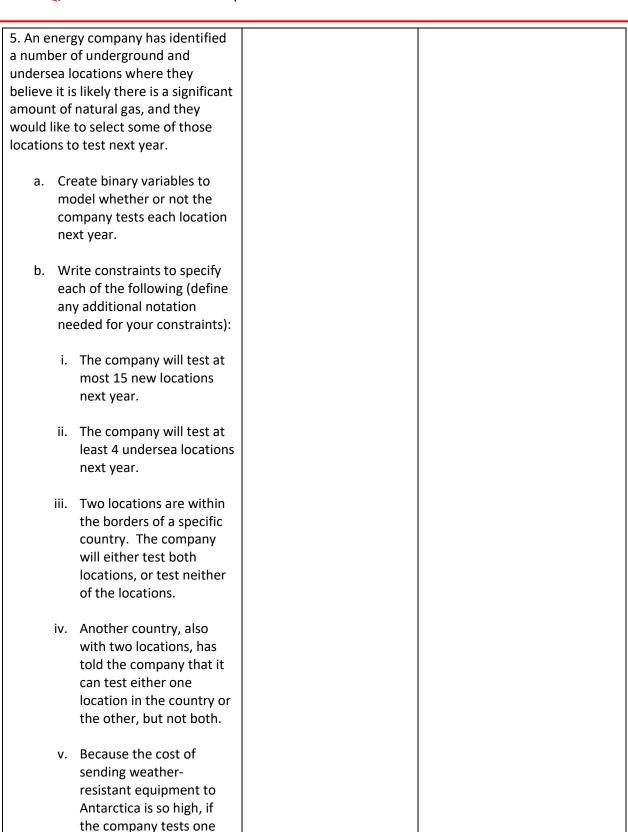| English	Math	gurobipy
1. A law office has been offered eight different cases, and needs to choose which ones among the eight to take on. Each case has an expected profit and an expected amount of person-time required. a. Create binary variables to model whether or not the office takes each case. (If you have done the previous assignment, you can reuse these variables.) b. Let w_i be a variable denoting the amount of office paper that will be purchased for each case i (up to a maximum of 10 reams). Write a constraint for each case to specify that if the office takes the case, at least 2 reams of paper will be purchased for the case.		

2. A manufacturer wants to rent warehouses in which to store raw materials before use. There are six different locations available for rent, each with a different annual rental cost and a different capacity.
 	
  a. Create binary variables to model whether or not the manufacturer rents each warehouse. (If you have done the previous assignment, you can reuse these variables.)
  b. Let z_i be a variable denoting the number of forklifts purchased for each warehouse i. Write a constraint for each warehouse to specify that at least f_i forklifts will be purchased for warehouse i if it is rented.		

3. A supermarket chain is considering expanding by placing new stores in up to 100 communities next year. For each community, the chain has built a model to predict annual store profit.
 	
  a. Create binary variables to model whether or not the chain puts a store in each community. (If you have done the previous assignment, you can reuse these variables.)
 	
  b. Let f_i be a variable denoting the fraction of each new supermarket i that will hold frozen items. Each community has a specific minimum fraction of frozen-item space that would be required. Write a constraint for each community to specify that at least the minimum fraction of frozen-items space will be created in that		

community's store if the store is built.		

4. A venture capital firm is trying to decide which startups to invest in this month.
 	
  a. Create binary variables to model whether or not the firm invests in each of the startups.
 	
  b. Write constraints to specify each of the following (define any additional notation needed for your constraints):
 	
    i. The firm will invest in at most 5 new startups.
 	
    ii. The firm will invest in at least 2 startups.
 	
    iii. Two entertainment-industry startups are being considered for funding. The firm will either invest in both or neither, but not just one or the other.
 	
    iv. Two agriculture-related startups are being considered for funding. The firm would like to make opposite decisions for them (either fund the first and not the second, or fund the second and not the first).
 	
    v. The company is considering four alternative energy startups. If the company invests in any of them, then it will invest in all four.		

5. An energy company has identified a number of underground and undersea locations where they believe it is likely there is a significant amount of natural gas, and they would like to select some of those locations to test next year.

    a.   Create binary variables to model whether or not the company tests each location next year.

    b.   Write constraints to specify each of the following (define any additional notation needed for your constraints):

        i.   The company will test at most 15 new locations next year.

        ii.   The company will test at least 4 undersea locations next year.

        iii.   Two locations are within the borders of a specific country. The company will either test both locations, or test neither of the locations.

        iv.   Another country, also with two locations, has told the company that it can test either one location in the country or the other, but not both.

        v.   Because the cost of sending weather-resistant equipment to Antarctica is so high, if the company tests one location in Antarctica, it

will test all of the locations in Antarctica.		

For each of the following mathematical or gurobipy constraints, write the corresponding English statement.

Background: As in question 5 above, an energy company has identified a number of underground and undersea locations where they believe it is likely there is a significant amount of natural gas, and they would like to select some of those locations to test next year. Assume that you have already created the binary variables in question 5 above, to model whether or not the company will test each location next year.

English	Math	gurobipy
6. No more than seven of the locations in Europe can be tested next year.		
7. At least five locations in the United States should be tested next year.		
8. The company will make opposite decisions (test, not test) for locations 17 and 46.		
9. The company will either test both locations in New Zealand, or not test either New Zealand location.		
10. The company will make opposite decisions about the test location in Mexico and the test location in Venezuela.		
11. No more than four of the locations tested can be in communist countries.		
12. At least six locations in North America must be tested.		
13. The company will test either the location in Canada or the location in Greenland, but not both.		

For each of the following sets of constraints, write the constraints and then determine whether the red constraint is implied by the other constraints. For each question, use the following variable definitions about marketing for a new product.

English	Math	gurobipy
Dollars spent on television ads in each of ten cities	$d_i \geq 0$: dollars spent on ads in city i	`#VARIABLES` `d = m.addVars(10, type = GRB.CONTINUOUS)`
Number of influencers paid on each of five social media platforms	$n_j \geq 0$ and integer: number of influencers paid on social media platform j	`#VARIABLES` `n = m.addVars(5, type = GRB.INTEGER)`
Dollars spent on influencers on each of five social media platforms	$s_j \geq 0$: dollars spent on influencers on social media platform j [Note: we can't call this d_j like two rows above, because d is already used for ad spend on each city, so something like d_1 would be ambiguous: ad spend in city 1 or influencer spend on social media platform 1.]	`#VARIABLES` `s = m.addVars(5, type = GRB.CONTINUOUS)`
Dollars spent for product placement in each of ten major new movies	$p_k \geq 0$: dollars spent on product placement in movie k	`#VARIABLES` `p = m.addVars(10, type = GRB.CONTINUOUS)`
Was money spent for product placement in each of ten major new movies? (1=yes, 0=no)	$x_k \in \{0,1\}$: where $x_k = 1$ denotes that money is spent on product placement in movie k, and $x_k = 0$ denotes that money is not spent on product placement in movie k	`#VARIABLES` `x = m.addVars(10, type = GRB.BINARY)`

English	Math	gurobipy
(1) The company will spend at least $1 million on television ads in every city. (2) The company will spend more than $20 million total on product placement in movies. (3) On each social media platform, the company cannot spend more than $5 million on influencers. (4) The total money spent on television ads and movie product placement must be at least as much as the money spent on influencers. Implied (yes or no)?		
(1) The company will spend at least $1 million on television ads in any city. (2) The company will spend more than $20 million total on product placement in movies. (3) On each social media platform, the company cannot spend more than $10 million on influencers. (4) The total money spent on television ads and movie product placement must be more than the money spent on influencers. Implied (yes/no)?		

(1) The number of influencers paid on each social media platform can be no more than two. (2) The company wants to have at least as many movies with product placements than it has social media influencers. Implied (yes/no)?		
(1) The number of influencers paid on each social media platform can be no less than two. (2) The company wants to have at least as many social media influencers as it has movies with product placements. Implied (yes/no)?		

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