Introduction to Optimization Through the Lens of Data Science Course Exercises

Exercises - Section 4: Lecture 13 – Using Sets and Indicator Data - Solutions

Suppose we have the following notation for a musical instrument manufacturer:

DESCRIPTION	MATH	GUROBI	
Index for instrument model	i	i	
Cost to manufacture each	C_i	cost = {i:	
instrument of model i (data)		<pre>get_cost(i) for i in</pre>	
		I}	
Number of instruments of	$\overline{X_i}$	x = m.addVars(cost,	
model i made (variable)		obj=cost)	

For each of the following descriptions, create the necessary set-based notation and set-based gurobipy code for the data and/or variables.

DESCRIPTION	MATH	GUROBI
1. Set of instrument models	S	S
that have silver plating		
	NOTE: Any other letter	
	you would be okay too,	
	except C or X because	
	those are already used for	
	cost and number.	
2. Set of instrument models	В	В
that are made for beginners		
3. Set of instrument models	Н	Н
that are sold to high schools		
4. Total silver-plated	$\sum X_i$	<pre>gp.quicksum(x[i] for i in S)</pre>
instruments made	$i \in S$	
5. Total beginner	$\sum X_i$	<pre>gp.quicksum(x[i] for i in B)</pre>
instruments made	$i \in B$	
6. Total cost to	$\sum c_i X_i$	<pre>gp.quicksum(cost[i] * x[i]</pre>
manufacture silver-plated	$i \in S$	for i in S)
instruments		
7. Total cost to	$\sum c_i X_i$	<pre>gp.quicksum(cost[i] * x[i]</pre>
manufacture high-school	$i\in H$	for i in H)
instruments		

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8. Total silver-plated beginner instruments made	$\sum_{i \in S, i \in B} X_i$	<pre>gp.quicksum(x[i] for i in set(S).intersection(set(B)))</pre>
	$\sum X_i$	or
	i∈S∩B	<pre>gp.quicksum(x[i] for i in S if i in B)</pre>
	NOTE: The notation $S \cap B$ means the intersection of	or .
	sets S and B; in other	or
	words, all the values of i	<pre>gp.quicksum(x[i] for i in B</pre>
	that are in both set S and set B.	if i in S)
9. Total silver-plated high- school instruments made	$\sum_{i \in S, i \in H} X_i$	<pre>gp.quicksum(x[i] for i in set(S).intersection(set(H))) or</pre>
	$\sum_{i \in S \cap H} X_i$	<pre>gp.quicksum(x[i] for i in S if i in H)</pre>
		or
		<pre>gp.quicksum(x[i] for i in H if i in S)</pre>
10. Total cost to manufacture silver-plated	$\sum c_i X_i$	<pre>gp.quicksum(cost[i]*x[i] for i in</pre>
beginner instruments	or $\sum_{i \in S, i \in B} c_i x_i$	<pre>set(S).intersection(set(B))) or</pre>
	$\sum_{i \in S \cap B} C_i X_i$	<pre>gp.quicksum(cost[i]*x[i] for i in S if i in B)</pre>
		or
		<pre>gp.quicksum(cost[i]*x[i] for i in B if i in S)</pre>
11. Total cost to manufacture silver-plated	$\sum C_i X_i$	<pre>gp.quicksum(cost[i]*x[i] for i in</pre>
high school instruments	or $\sum_{i \in S, i \in H} C_i X_i$	<pre>set(S).intersection(set(H))) or</pre>
	$\sum_{i \in S \cap H} C_i X_i$	<pre>gp.quicksum(cost[i]*x[i] for i in S if i in H)</pre>
		or
		<pre>gp.quicksum(cost[i]x[i] for i in H if i in S)</pre>

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12. Total non-silver instruments made	$\sum_{i \notin S} X_i$	<pre>gp.quicksum(x[i] for i in I if i not in S)</pre>
	Here, to add up all models that are not silver, it is necessary to sum over all values of i that are <u>not</u> in the silver set S.	
13. Total non-beginner instruments made	$\sum_{i \notin B} X_i$	<pre>gp.quicksum(x[i] for i in I if i not in B)</pre>
14. Total cost to manufacture non-silver instruments	$\sum_{i \notin S} C_i X_i$	<pre>gp.quicksum(cost[i] * x[i] for i in I if i not in S)</pre>
15. Total non-silver beginner instruments made	$\sum_{i \notin S, i \in B} X_i$	<pre>gp.quicksum(x[i] for i in B if i not in S)</pre>
16. Total cost to manufacture non-silver, non-beginner instruments	$\sum_{i \notin S, i \notin B} C_i X_i$	<pre>gp.quicksum(x[i] for i in I if i not in S if i not in B)</pre>

For each of the following descriptions, create the necessary indicator-data-based notation and indicator-data-based gurobipy code for the data and/or variables.

DESCRIPTION	MATH	GUROBI
1. Indicator data vector to show	S_i	Sind = {i: 1 if i in
which instrument models that		S else 0 for i in I}
have silver plating	NOTE: Any other letter you	
	would be okay too, except C or	
	X because those are already	
	used for cost and number.	
2. Indicator data vector to show	B_i	Bind = {i: 1 if i in
which instrument models are		B else 0 for i in I}
made for beginners		
3. Indicator data vector to show	H_i	Hind = {i: 1 if i in
which instrument models that		H else 0 for i in I}
are sold to high schools		
4. Total silver-plated	$\sum S_i X_i$	<pre>gp.quicksum(Sind[i] *</pre>
instruments made	$\sum_{i}^{S_{i}n_{i}}$	x[i] for i in I)
5. Total beginner instruments	$\sum B_i X_i$	<pre>gp.quicksum(Bind[i] *</pre>
made	$\left \begin{array}{c} \sum_{i}^{D_{i} n_{i}} \end{array} \right $	x[i] for i in I)
6. Total cost to manufacture	$\sum S_i C_i X_i$	<pre>gp.quicksum(Sind[i] *</pre>
silver-plated instruments	$\angle i^{S_i C_i X_i}$	cost[i] * x[i] for i
	t .	in I)

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7. Total cost to manufacture high-school instruments	$\sum_i H_i C_i X_i$	<pre>gp.quicksum(Hind[i] * cost[i] * x[i] for i in I)</pre>
8. Total silver-plated beginner instruments made	$\sum_{i} S_{i} B_{i} X_{i}$	<pre>gp.quicksum(Sind[i] * Bind[i] * x[i] for i in I)</pre>
9. Total silver-plated high- school instruments made	$\sum_{i} S_{i} H_{i} X_{i}$	<pre>gp.quicksum(Sind[i] * Hind[i] * x[i] for i in I)</pre>
10. Total cost to manufacture silver-plated beginner instruments	$\sum_i S_i B_i C_i X_i$	<pre>gp.quicksum(Sind[i] * Bind[i] * cost[i] * x[i] for i in I)</pre>
11. Total cost to manufacture silver-plated high school instruments	$\sum_{i} S_{i} H_{i} C_{i} X_{i}$	<pre>gp.quicksum(Sind[i] * Hind[i] * cost[i] * x[i] for i in I)</pre>
12. Total non-silver instruments made	$\sum_{i} (1 - S_i) X_i$	<pre>gp.quicksum((1 - Sind[i]) * x[i] for i in I)</pre>
	NOTE: To count all of the non- silver instruments, $(1 - S_i)$ can be used, so if an instrument is silver ($S_i = 1$), then X_i is multiplied by zero, and if an instrument is not silver ($S_i = 0$), then X_i is multiplied by one.	
13. Total non-beginner instruments made	$\sum_{i} (1 - B_i) X_i$	<pre>gp.quicksum((1 - Bind[i]) * x[i] for i in I)</pre>
14. Total cost to manufacture non-silver instruments	$\sum_{i} (1 - S_i) C_i X_i$	<pre>gp.quicksum((1 - Sind[i]) * cost[i] * x[i] for i in I)</pre>
15. Total non-silver beginner instruments made	$\sum_{i} (1 - S_i) B_i X_i$	<pre>gp.quicksum((1 - Sind[i]) * Bind[i] * x[i] for i in I)</pre>
16. Total cost to manufacture non-silver, non-beginner instruments	$\sum_{i} (1 - S_i)(1 - B_i)C_iX_i$	<pre>gp.quicksum((1 - Sind[i]) * (1 - Bind[i]) * x[i] for i in I)</pre>

NOTES:		

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