Exercises - Section 4: Lecture 11 - Notation Subscripts Summations - **Solutions**

Traditionally, optimization experts use letters at the beginning of the alphabet to denote data – things that the optimization model can't suggest changes to, like the cost of purchasing a raw material or the forecasted demand for a product. The tradition for variables is to start with *x*, *y*, and *z*, and then go back to *w* and work backwards.

I'm not sure exactly where the tradition came from, but by now this is what we're stuck with – so let's go ahead and embrace it!

[Note, though, that there are exceptions. For example, some modelers use letters that match what's being modeled – for example, P for price, C for cost, T for temperature, etc. You can use whatever you want, as long as you clearly define the terms.]

Suppose we have the following notation for a rental car fleet planning model:

DESCRIPTION	MATH	GUROBIPY
Forecasted rental demand for small cars (forecasted data)	A	A (typically declared with a value, e.g., A = 10, or read from a file)
Forecasted rental demand for midsize cars (forecasted data)	B	B
Forecasted rental demand for luxury cars (forecasted data)	C	C
Forecasted rental demand for SUVs (forecasted data)	D	D
Forecasted rental demand for minivans (forecasted data)	E	E
Cost per small car (known data)	F	F
Cost per midsize car (known data)	G	G
Cost per luxury car (known data)	H	H
Cost per SUV (known data)	I	I
Cost per minivan (known data)	J	J
Number of small cars to purchase (variable)	X	X = model.addVar(name = 'X')
Number of midsize cars to purchase (variable)	Y	Y = model.addVar(name = 'Y')
Number of luxury cars to purchase (variable)	Z	Z = model.addVar(name = 'Z')
Number of SUVs to purchase (variable)	W	W = model.addVar(name = 'W')
Number of minivans to purchase (variable)	V	V = model.addVar(name = 'V')

Fill in the table below, using the notation above to describe each of the following quantities mathematically and in Python.

QUESTION	MATH	GUROBIPY
1. Forecasted rental demand for luxury cars	C	C
2. Forecasted rental demand for SUVs	D	D
3. Cost per SUV	I	I
4. Number of small cars to purchase	X	X (or X.x if you want the value of X)
5. Forecasted demand for midsize cars and minivans	$B + E$	B+E
6. Forecasted rental demand for cars (not SUVs or minivans)	$A + B + C$	A+B+C
7. Total cars to purchase above midsize	$Z + W + V$	Z+W+V
8. Total vehicles to purchase	$X + Y + Z + W + V$	X+Y+Z+W+V
9. Cost of midsize cars purchased	GY	G*Y
10. Cost of SUVs purchased	IW	I*W
11. Cost of midsize cars and minivans purchased	$BY + JV$	B*Y+J*V
12. Cost of SUVs and minivans	$IW + JV$	I*W+J*V
13. Cost of all cars (not SUVs or minivans) purchased	$FX + GY + HZ$	F*X+G*Y+H*Z
14. Cost of all vehicles purchased	$FX + GY + HZ + IW + JV$	F*X+G*Y+H*Z+I*W+J*V
15. Forecasted purchase cost per rental of SUVs	$\dfrac{IW}{D}$	I*W / D
16. Forecasted purchase cost per rental of minivans	$\dfrac{JV}{E}$	J*V / E
17. Average purchase cost over all SUVs and minivans	$\dfrac{IW + JV}{W + V}$	(I*W+J*V)/(W+V)
18. Average purchase cost of all cars (not SUVs or minivans)	$\dfrac{FX + GY + HZ}{X + Y + Z}$	(F*X+G*Y+H*Z)/(X+Y+Z)
19. Forecasted purchase cost per rental over all cars (not SUVs or minivans)	$\dfrac{FX + GY + HZ}{A + B + C}$	(F*X+G*Y+H*Z)/(A+B+C)
20. Forecasted purchase cost per rental over all vehicles	$\dfrac{FX + GY + HZ + IW + JV}{A + B + C + D + E}$	(F*X+G*Y+H*Z+I*W+J*V)/(A+B+C+D+E)

NOTES: