AADM Excel

Excel Solver demonstration

0.1 Defining the problem

In excel, the cell that should contain the optimal value of our **objective function** is known as the **target cell**. The decision variables that can be varied are called the **changing cells**. We essentially change these values so as to obtain an optimal objective function value. Lastly, we keep track of **constraints**. We as a typical example we will consider the **diet optimization** problem. Consider 4 types of food with various nutritional values and units costs.

$$\begin{bmatrix} & \boldsymbol{Browny} & \boldsymbol{IceCream} & \boldsymbol{Cola} & \boldsymbol{Cake} \\ \boldsymbol{Calories} & 400 & 200 & 150 & 500 \\ \boldsymbol{Cholocate} & 3 & 2 & 0 & 0 \\ \boldsymbol{Sugar} & 2 & 2 & 4 & 4 \\ \boldsymbol{Fat} & 2 & 4 & 1 & 5 \\ \boldsymbol{Cost} & \$0.50 & \$0.20 & \$0.30 & \$0.80 \end{bmatrix} \tag{1}$$

Now our task is to find a **minimum cost diet** that contains:

- At least 500 Calories.
- At least 6 grams of Chocolate.
- At least 10 grams of Sugar.
- At least 8 grams of Fat.

0.2 Formulating the problem

First we identify our decision variables. In our example these are the quantities of different food items to eat. In the table below we are choosing to eat 3 Brownies, 0 ice creams and so on.

Decision Variables				
	Browny	IceCream	Cola	Cake
Quantity to eat	3	0	1	7

Figure 1: *decision variables*

Now we have to set up the objective function. Note that the objective function is about **minimizing cost** under certain constraints. So for computing cost we simply take the product of each food item with its unit cost and add these expressions across all the food items available. We can use the **SumProduct** function in Excel here. It takes as an input 2 ranges of values or 2 rows/columns. The first element of the first row is multiplied with the corresponding first element of the second row and then that expression is added to a similarly computed expression for the second elements, and so on. Here we have the initially computed objective function value, based on random quantities we entered previously.

Objective Function				
	Browny	IceCream	Cola	Cake
Qauntity to eat	3	0	1	7
cost per unit	50	20	30	80
TOTAL	740			
	"=SUMPRODUCT(C12:F12, C13:F13)"			

Figure 2: *objective function*

0.3 Setting up the constraints

Now to set up the constraints, we take take the original food table that lists out the amount of calories and units of units of nutritional elements present in each food type. This is necessary since it will give us a count of the total amount of nutritional elements and calories our decision variable choice is giving us - ideally our decision variable choice should satisfy the limiting constraints on things like calories, chocolate, fat and sugar levels. We basically take the **sum product** of our decision variable quantities with the corresponding amount of calories, chocolate level, fat and sugar level (which are the constraints) and set the overall value of the **sum product** as less than or equal to the constraining value mentioned. It is shown in the figure below. Note that we calculate the **sum product of the decision variable quantity with each constraining variable - which happen to be the measures of calories, chocolate, sugar and fat**. Note that the **conditional signs** under the column **condition** represent the fact that the overall measure with respect to constraining variables must be ’greater than or equal to’ a specific constraining value. Subsequently in figure 4 the complete LP problem is laid out.

Objective Function				
	Browny	IceCream	Cola	Cake
Qauntity to eat	3	0	1	7
cost per unit	50	20	30	80
TOTAL	740			
	"=SUMPRODUCT(C12:F12, C13:F13)"			

	Browny	IceCream	Cola	Cake	Totals	Condition	Required
Calories	400	200	150	500	=SUMPRODUCT(C12:F12, C21:F21)	>=	500
Chocolate	3	2	0	0		>=	6
Sugar	2	2	4	4		>=	10
Far	2	4	1	5		>=	8

Figure 3: *computing with constraints*

Decision Variables				
	Browny	IceCream	Cola	Cake
Quantity to eat	3	0	1	7

Objective Function				
	Browny	IceCream	Cola	Cake
Qauntity to eat	3	0	1	7
cost per unit	50	20	30	80
TOTAL	740			
	"=SUMPRODUCT(C12:F12, C13:F13)"			

Constraints	Browny	IceCream	Cola	Cake	Totals	Condition	Required
Calories	400	200	150	500	4850	>=	500
Chocolate	3	2	0	0	9	>=	6
Sugar	2	2	4	4	38	>=	10
Fat	2	4	1	5	42	>=	8

Figure 4: *The LPP: with decision variables, objective function and constraint specified*

0.4 Actually solving

Now in excel we go to **DATA** and then to **SOLVER** and open up the solver box. Now we will first identify the cell that is meant to store the value of our objective function. This **target cell** is filled in the **set objective box**. After that we specify whether our LPP is a min or max problem. In this problem we are minimizing cost so we select min. Also we will specify the decision cells in the **by changing variable cells box**. With this we are telling excel to compute the minimum of our objective function by changing the decision variables, that is the quantities of food items.

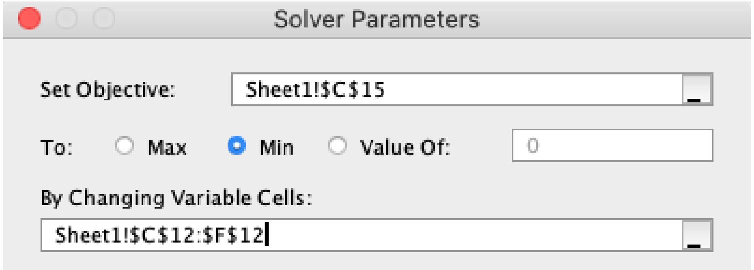

Figure 5: *specifying LPP parameters*

Now we start adding the constraint conditions by clicking on the **add constraint box** in which we first specify the **constraint** which is the fixed amount of the constraining variable (in our case, for example, calories are constrained be atleast 500). Next in the **cell reference** we input the total value for each constraint that is computed using our varying decision variables, as demonstrated in figure 3 under the column **totals**. Finally we enter the type of condition and then add the final constraints. In the subsequent figure we can see all the constraints added. Lastly make sure to check the box that says **make unconstrained nonnegative**. With this we ensure that any unconstrained variables would be greater than or equal to zero. Finally we can select a **solving method** as **simplex** for a typical LPP and then click on solve. We will find out target variable optimized.

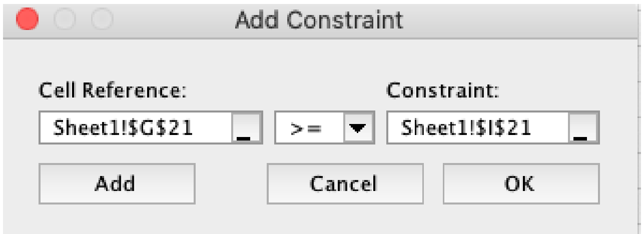

Figure 6: *adding constraints*

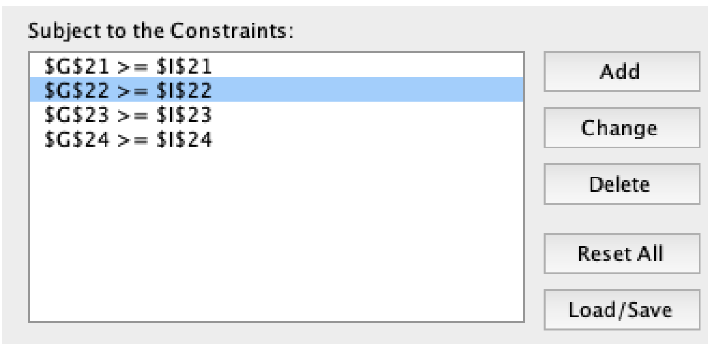

Figure 7: *adding constraints*

0.5 Outputting the final value

After setting up the classic diet problem and setting all the conditions for decision variables, objective function and constraints, we have our final solution as shown below. What this says is that to optimize/minimize our cost under the given constraints of consumption, we must have eat 0 brownies, 3 ice creams, 1 cola and 0 cakes which would cost us a minimal amount of $\$90$, while also satisfying our constraints of eating calories more than 500, having nutitional level of chocolate more than 6, sugar level more than or equal to 10 and fat level more than 8.

Decision Variables				
	Browny	IceCream	Cola	Cake
Quantity to eat	3	0	1	7

Objective Function				
	Browny	IceCream	Cola	Cake
Qauntity to eat	0	3	1	0
cost per unit	50	20	30	80
TOTAL	90			
	"=SUMPRODUCT(C12:F12, C13:F13)"			

Constraints	Browny	IceCream	Cola	Cake	Totals	Condition	Required
Calories	400	200	150	500	750	>=	500
Chocolate	3	2	0	0	6	>=	6
Sugar	2	2	4	4	10	>=	10
Fat	2	4	1	5	13	>=	8

Figure 8: *output*