(Four trucks) Four trucks are available to deliver milk to five grocery stores. The capacity and daily operating cost of each truck are shown in the file P06_82xlsx. The demand of each grocery store can be supplied by only one truck, but a truck can deliver to more than one grocery. The daily demands of each grocery are listed in the same file. Determine how to minimize the daily cost of meeting the demands of the five groceries.

P06_82.xlsx

Milk delivery data				
Truck	1	2	3	4
Daily operating cost	$65	$65	$70	$80
Capacity (gallons)	400	500	600	700

Discussion: -

In this problem, our objective is to minimize the daily cost by making sure that milk is delivered to all the groceries. Cost is directly proportional to the usage of number of trucks. Our optimal solution should choose the trucks and inform us the quantity which can be delivered to the groceries. So, our decision variables will be whether we are using the truck or not and whether we are using the truck for delivering the milk to store or not. We have a constraint that each grocery store can be supplied by only one truck, so we must make sure that it is met. On top of this our solution should make sure that each groceries demand is met. To meet this, we must create a calculated field which records the quantity deliver by truck to the grocery.

Mathematical Model: -

Parameters (Inputs):

$i \in 1,2,3,4$ (i: $Index\ for\ trucks$)
$j \in 1,2,3,4,5$ (i: $Index\ for\ grocery\ stores$)
F_i : $Daily\ operating\ cost\ of\ truck\ i$
C_i : $Capacity\ of\ truck\ i$
D_j : $Demand\ from\ grocery\ j$

Decision Variables:
x_i : $Decision\ on\ whether\ truck\ i\ is\ used\ or\ not$
y_{ij} : $Decision\ on\ whether\ truck\ i\ delivered\ milk\ to\ grocery\ j$

Objective:

$$Minimize\ total\ \ cost = \sum_{i=1}^{4} x_i * F_i$$

Constraints:

$$\sum_{i=1}^{4} y_{ij} \leq 1 \ ; For\ j \in \{1,2,3,4,5\} \qquad (1)\ Delivery\ constraint$$

$x_i \,\&\, y_{ij} \in \{0,1\}$ (2) *Binary Constraint*

$$\sum_{i=1}^{4} y_{ij} * D_j \geq D_j \quad ; For\ j \in \{1,2,3,4,5\}$$ (3) *Quantity Delivered constraint*

$$\sum_{j=1}^{5} y_{ij} * D_j \leq C_i \quad ; For\ i \in \{1,2,3,4\}$$ (4) *Truck Capacity constraint*

Constraint 1 will make sure that a grocery is supplied by only one truck. Because of constraint 1 we clearly know that if truck T1 is assigned to grocery G1, quantity delivered by truck 1 to grocery 1 is the equal to the demand of grocery 1. Calculated field will record this value and constraint 3 will make sure that supply meets the groceries demand. Truck capacity is bounded with constraint 4.

Excel Implementation: Please find the attached spreadsheet for solution.

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Milk delivery data									Inputs
Truck	1	2	3	4		Total Cost	280		Decision variables
Daily operating cost	$65	$65	$70	$80					Calculated Variables
Capacity (gallons)	400	500	600	700					Constraints
									Objective
	T1	T2	T3	T4					
Decision	1	1	1	1					
Decision	T1	T2	T3	T4					
G1	1	0	0	0	1	<=	1		
G2	0	0	0	1	1	<=	1		
G3	0	0	0	1	1	<=	1		
G4	0	1	0	0	1	<=	1		
G5	0	0	1	0	1	<=	1		
Calculated Field	T1	T2	T3	T4			Demand		
G1	200	0	0	0	200	>=	200		
G2	0	0	0	400	400	>=	400		
G3	0	0	0	300	300	>=	300		
G4	0	500	0	0	500	>=	500		
G5	0	0	600	0	600	>=	600		
	200	**500**	**600**	**700**					
	<=	<=	<=	<=					
Capacity	400	500	600	700					