**Problem 2.24 & 4.9**

**Identifying decision variables:** Let X1 be acres to plant watermelons and X2 be acres to plant cantaloupes

=>X1+X2<=100

**Objective function**

Given that watermelon requires 20 pounds of fertilizer per acre, costing $10 per 50 pounds bag

=>10/50\*20=4

Similarly, cantaloupes require 15 pounds of fertilizer per acre, costing same as $10 per 50 pounds bag

=>10/50\*15=3

It takes 2 hours to plant an acre with watermelons and 2.5 hours to plant an acre of cantaloupes and labor charge for planting is $5

=> it costs 2\*5=$10 for watermelons and 2.5\*5=$12.5 for cantaloupes

The expected yield for watermelons and cantaloupes is 90 and 300 with selling price of $3 and $1 respectively

=>Revenue=$270 and $284.5 for watermelons and cantaloupes respectively

Finally, calculating profit from above derivations, we get

=>270-(10+4) = 256 for watermelons

=>300-(12.5+3) = 284.5 for cantaloupes

Hence **objective function** is to maximize profits

=>256X1+284.5X2

**Constraints**

Total acres of land is 100

=>X1+X2<=100

Watermelons and cantaloupes require 50 and 75 gallons of water per day per acre and farmer can yield 6000 gallons to the field

=>50X1+75X2<=6000

Also bounding to X1>=0 and X2>=0

The above functions give the following result from analytic solver

X1=60 acres and X2=40 acres

The following results are extracted from the answer and solver reports generated in the solver, attached as excel Problem 4.9

**From table Constraints:**

Total profit increases by $1.14 for every 1 gallon of water used extra and for every acre of land farmed profit increases by $199.

**From table Decision variable cells:**

Here the profit made by selling watermelons and selling price of watermelons are synonymous since to achieve profit a constant value is being subtracted from the price and multiplied by acres of land farmed.

The profit made by selling an acre of watermelons can increase by $28.5 and decrease by $66.334 without affecting the optimal solution.

The profit made by selling an acre of cantaloupes can increase by $99.5 and decrease by $28.5 without affecting the optimal solution.

**Problem 4.9 solutions:**

1. The price on watermelons can drop by $66.334(to 256-66.334=189.666) per acre.
2. The price on cantaloupes can increase by $99.5(to 284.5+99.5=384) per acre.
3. Drop in the price of watermelon = $60 per acre

Drop in the price of cantaloupes = $50 per acre

Original price of watermelon= $270 per acre

Original price of cantaloupes= $300 per acre

Decreased price of watermelon = $210 per acre and $70 per each

Decreased price of cantaloupes = $250 per acre and $250 per each

After inserting updated prices in the model and executing it, the optimal solution is $21140 which is different from before.

So, the optimal solution changes. (4.9c sheet in excel workbook)

1. Based on the Constraints table in the Sensitivity report, the farmer can lease up to 20 acres of land. So the farmer makes a profit of 20 \* 199 = 3980 by farming 20 acres of land, which implies the farmer should be willing to pay $3980 amount of money and use the available water to farm extra land so that optimal solution is still the same.

**Problem 6.8**

**Identifying decision variables:** Let X(i,j) represent delivering the car i with truck j

Where i is the variable representing Cars is of subset {1,2,3,4} and j is the variable representing Trucks of subset {1,2,3,4,5}

Hence the **objective function** is to **minimize** the cost of delivery

=>276X11+179X12+150X13+97X14+305X15+497X21+375X22+475X23+163X24+150X25+251X31+298X32+344X33+285X34+225X35+364X41+190X42+492X43+185X44+165X45

**Identifying constraints**

The car delivery should bound to truck capacity

=>276X11+497X21+251X31+364X41=2

179X12+375X22+298X32+190X42=1

150X13+475X23+344X33+492X43=1

97X14+163X24+285X34+185X44=1

305X15+150X25+225X35+165X45=2

The car delivery is possibly an integer with binary variable representing either delivering the car by the represented truck {1} or not delivering by that truck {0}.

This comes up to the constraint that each car can be delivered once,

=>X11+X12+X13+X14+X15=1

X21+X22+X23+X24+X25=1

X31+X32+X33+X34+X35=1

X41+X42+X43+X44+X45=1

The decision variables are cars, can only be integers,

=>X11, X12, X13, X14, X15, X21, X22, X23, X24, X25, X31, X32, X33, X34, X35, X41, X42, X43, X44, X45 bound to be integers

The lower limit of the cars, X11, X12, X13, X14, X15, X21, X22, X23, X24, X25, X31, X32, X33, X34, X35, X41, X42, X43, X44, X45 should be >=0

Output from Analytic solver is shown in below figure (Also attached as excel Problem 6.8)

Solver shows that to minimize the cost of delivery, truck 2 should take car 4, truck 4 to car 1 and truck 5 to deliver cars 2,3 to give a minimum cost of $662

Given that Bowden charges the car buyer a flat fee of $600 to pick up and deliver each car and keeps 50% of profit earned

=>600\*4=$2400 =>2400-662=1738

50% of profit is kept by Bowden => 1738\*50/100 = 869 is the maximum profit earned in this trip

