Assignment 3: Pivot Tables and Linear Programming

Date Due: September 18, 2013 Instructor: Trani

Problem 1

A bus leasing company has hundreds os buses placed in 5 cities around the country. The bus data is shown below and provided to you in a file called BusCompany_2013.xls.

Table 1. Sample Bus Data for Bus Leasing Company.

A	B	C	D	E
City	Bus Type	Age	Miles	Route length
Charlotte	New Flyer MiDi35	7	398,324.0	25.6
Charlotte	New Flyer MiDi35	8	335,600.0	42.0
Seattle	New Flyer XDE40	9	552,353.4	34.0
Charlotte	New Flyer MiDi35	10	462,929.5	42.0
Salt Lake City	New Flyer XDE40	6	219,703.2	46.0
Salt Lake City	New Flyer XDE40	5	194,856.5	33.7
Atlanta	New Flyer XDE40	8	531,048.3	24.6
Seattle	New Flyer XDE40	8	287,000.0	32.3
Salt Lake City	New Flyer XDE40	4	143,900.0	33.6

where:

Column A = City where leased bus is located

Column B = Bus type and model

Column C = Age of the vehicle

Column D = Miles in the odomoter

Column E = Average route length (miles) for the vehicle

Task 1:

Using Excel create a Pivot Table to display the average number of miles in the odometer as a function of bus type, age of vehicle and city. Show a screen capture of the Pivot Table created.

		Data	
Bus Type	City	Average of Miles	Average of Age
New Flyer Mi	Atlanta	334875.676	6.528301887
	Charlotte	368674.3259	7.384615385
	Los Angeles	352062.3101	7.177777778
	Salt Lake City	369084.2101	7.365853659
	Seattle	367258.1594	7.186440678
New Flyer MiDi35 Total		358251.855	7.116
New Flyer XD	Atlanta	391434.4136	7.538461538
	Charlotte	369911.3251	7.52
	Los Angeles	399861.3698	7.416666667
	Salt Lake City	335907.4078	6.916666667
	Seattle	321361.9426	6.757575758
New Flyer XDE40 Total		361276.3079	7.204545455
Orion VII	Atlanta	382200.2304	7.428571429
	Charlotte	350600.6871	7
	Los Angeles	341347.9909	6.941176471
	Salt Lake City	345538.6362	7.206896552
	Seattle	367087.9107	7.25862069
Orion VII Total		358621.9373	7.180232558
Van Hol AGG	Atlanta	361961.1911	7.806451613
	Charlotte	349786.412	7.173913043
	Los Angeles	332114.5637	7.111111111
	Salt Lake City	350709.9272	7
	Seattle	374472.1269	7.384615385
Van Hol AGG300 Total		353723.8319	7.278074866
Grand Total		357733.8275	7.187584345

Task 2:

Using the Pivot Table created in Task 1 find the average mileage for all bus types in the fleet.

Answer:

357733.8275 mile

Task 3:

Using Excel create a Pivot Table to display the average number of miles in the odometer as a function of bus type, age of vehicle for the City of Charlotte. Show a screen capture of the Pivot Table created.

City	Charlotte	
	Data	
Bus Type	Average of Miles	Average of Age
New Flyer MiDi35	368674.3259	7.384615385
New Flyer XDE40	369911.3251	7.52
Orion VII	350600.6871	7
Van Hol AGG300	349786.412	7.173913043
Grand Total	360087.9372	7.280821918

Task 4:

Using the Pivot Table created in Task 3 find the average route length traveled by the Van Hol AGG300 buses leased by the City of Seattle.

City	Seattle
Average of Route length	
Bus Type	Total
Van Hol AGG300	37.84181715
Grand Total	37.84181715

Task 5:

Using Excel create a Pivot Table to count the number of buses as a function of bus type for all cities. Show a screen capture of the Pivot Table created.

City	(All)
Count of Bus Type	
Bus Type	Total
New Flyer MiDi35	250
New Flyer XDE40	132
Orion VII	172
Van Hol AGG300	187
Grand Total	741

Task 6:

Using the Pivot Table created in Task 5 find the city with the highest number of New Flyer MiDi35 buses with 6 years of age.

Answer:

Atlanta and Seattle has the highest number of New Flyer MiDi35 buses with 6 years of age, which is 11 for both.

Task 7:

Using Excel create a Pivot Table to summarize the total miles traveled by the buses as a function of bus type and city. Show a screen capture of the Pivot Table created.

Sum of Miles		
City	Bus Type	Total
Atlanta	New Flyer MiDi35	17748410.83
	New Flyer XDE40	10177294.75
	Orion VII	10701606.45
	Van Hol AGG300	11220796.92
Atlanta Total		49848108.96
Charlotte	New Flyer MiDi35	19171064.95
	New Flyer XDE40	9247783.127
	Orion VII	8063815.803
	Van Hol AGG300	16090174.95
Charlotte Total		52572838.83
Los Angeles	New Flyer MiDi35	15842803.95
	New Flyer XDE40	9596672.876
	Orion VII	11605831.69
	Van Hol AGG300	11956124.29
Los Angeles Total		49001432.81
Salt Lake City	New Flyer MiDi35	15132452.62
	New Flyer XDE40	8061777.787
	Orion VII	10020620.45
	Van Hol AGG300	12274847.45
Salt Lake City Total		45489698.31
Seattle	New Flyer MiDi35	21668231.41
	New Flyer XDE40	10604944.11
	Orion VII	21291098.82
	Van Hol AGG300	14604412.95
Seattle Total		68168687.28
Grand Total		265080766.2

Task 8:

Using the Pivot Table created in Task 7 find the city with the highest mileage on Orion VII buses.

Answer:

Seattle is the city with the highest mileage on Orion VII buses, which is 21291098.8 mile.

Problem 2

A company makes two Portland Cement Concrete (PCC) mixes for highway construction projects. Product Xcel is a premium PCC mix that sells for $175 per cubic meter. Product Performer ST is a PCC mix that sells for $154 per cubic meter.

With the mixing hardware available, the company can produce up to 640 cubic meters of the Xcel PCC mix per day or up to 780 cubic meters of the Performer ST product. Because the PCC concrete mixes are produced using the same machinery, linear combinations of both products not exceeding their maximum individual productions can be produced in one day. For example, the company could produce 530 cu. meters of the Perfomer ST mix and 205 cu. meters of the Xcel mix on the same day if we assume a linear combination of the individual production rates of the two PCC mixes. The company employs special trucks to deliver the concrete to various clients in the region. Because the specific weight of both products is not the same, the delivery trucks can haul up to 700 cu. meters of the Xcel PCC mix per day or up to 730 cu. meters per day of the Perfomer ST PCC mix. Linear combinations of both products not exceeding their maximum individual hauling rates can be delivered in one day. For example, the company could haul 360 cu. meters of the Perfomer ST mix and 350 cu. meters of the Xcel mix on the same day if we assume a linear combination of the individual hauling rates of the two distinct PCC mixes.

Task 1:

Formulate the problem as a linear programming problem. Assume the company wants to maximize the revenue for the company.

Answer:

Variables:

The amount of Xcel PCC mix produced per day is X_1

The amount of Performer ST produced per day is X_2

Objective:

Maximize avenue: $\mathrm{Z} = 175 \times \mathrm{X}_1 + 154 \times X_2$

S.T.

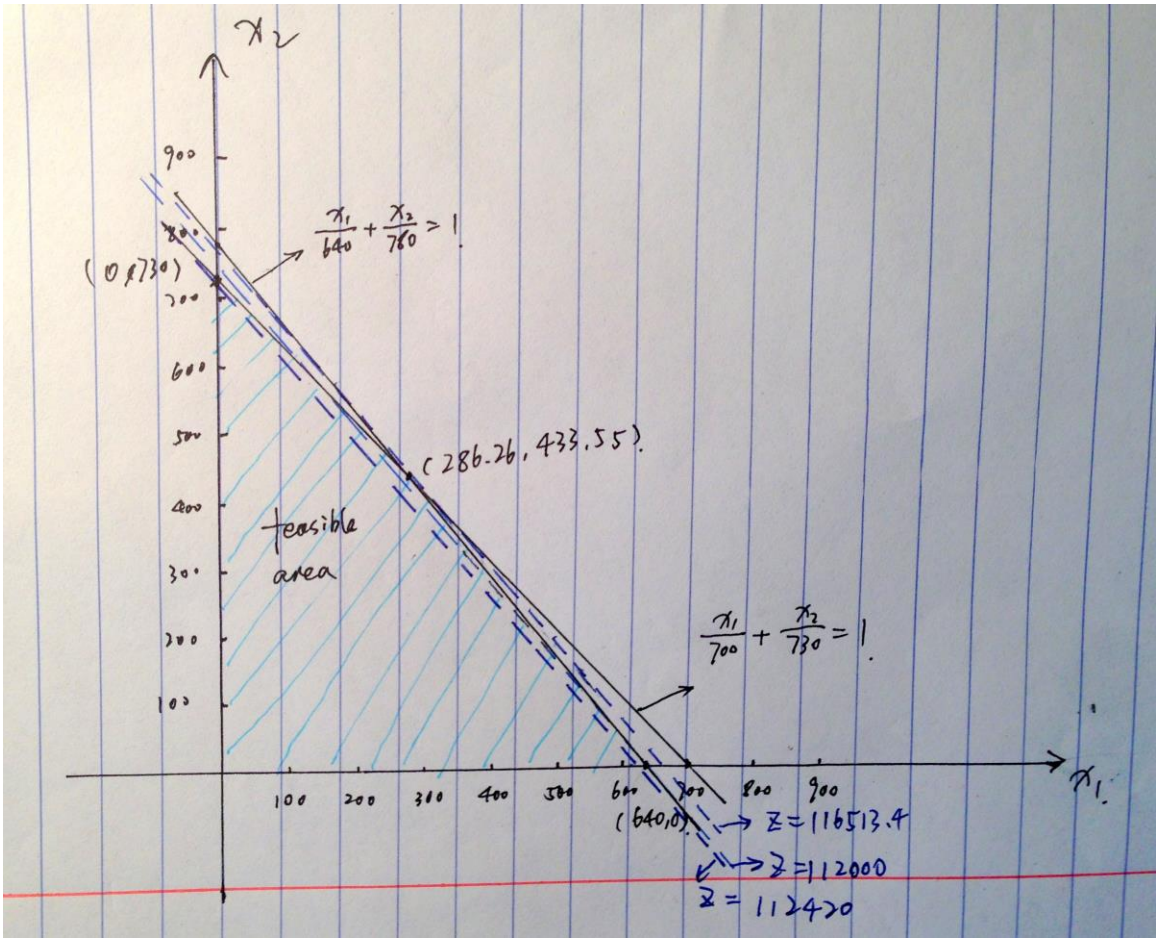
$\frac{\mathrm{X}_1}{640} + \frac{X_2}{780} \leq 1$

$\frac{\mathrm{X}_1}{700} + \frac{X_2}{730} \leq 1$

$\mathrm{X}_1, \mathrm{X}_2$ are non-negative

Task 2:

Solve the problem graphically. Clearly indicate corner points and plot the lines of constant Z value.



Optimal solution:

X1=284.26, X2=433.55, Z=116513.4

Task 3:

Solve the problem by hand using the Simplex Method. Clearly show your tables and indicate which variables are the basic variables in the current solution. Assume all constrains are of the type <= like the problem solved in class.

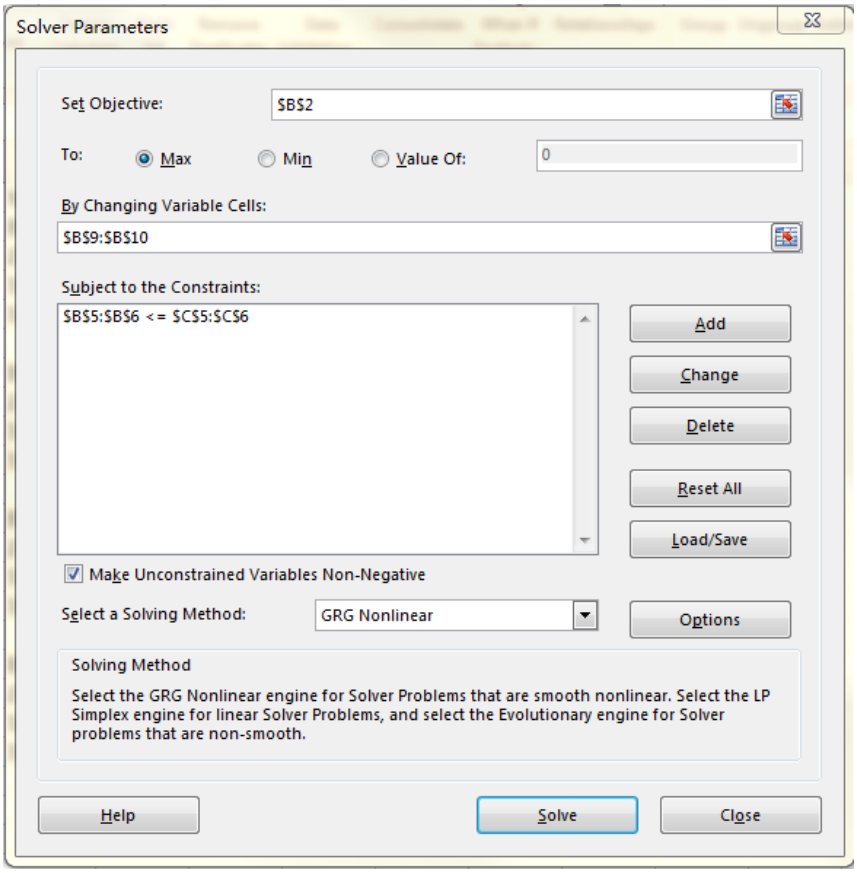
BV	Z	X1	X2	X3	X4	RHS
Z	1	-175	-154	0	0	0
X3	0	780	640	1	0	499200
X4	0	730	700	0	1	511000

BV	Z	X1	X2	X3	X4	RHS
Z	1	0	13.80822	0	0.239726	122500
X3	0	0	-107.945	1	-1.06849	-46800
X1	0	1	0.958904	0	0.00137	700

BV	Z	X1	X2	X3	X4	RHS
Z	1	0	0	0.127919	0.103046	116513.4
X2	0	0	1	-0.00926	0.009898	433.5533
X1	0	1	0	0.008883	-0.00812	284.264

Task 4:

Solve the PCC mix problem using Excel Solver. Comment on the results obtained in Tasks 3 and 4. Do they agree?



Result:

Variable	
X_1	284.2639
X_2	433.5533

obj	
Z=175×X_1+154×X_2	116513.4

Comment:

These three methods agree to each other.

Problem 3

Modify the water management pollution control problem described in the class notes and explained in class. New removal costs are presented in Table 1.

Table 1. Removal Costs and Pollution Values for Water Pollution Control Problem.

Source	Removal Cost ($/kg)	Pollution to Lake (kg)
River A	35	23,400
River B	46	12,800
River C	50	28,600
City	87	17,400
Airport	76	19,400

Assume that under a new water mandate by EPA we would like to remove at least 62,000 kg. of the baseline pollution going into the lake. Moreover, airport and city managers want to participate in the pollution removal program by removing at least 50% of their baseline pollution allocations per year. The pollution processing plants at all three rivers need to remove at least a quarter of their pollutants as a minimum according to a new environmental law.

a) Formulate the problem as a linear programming problem. Solve the new problem using Excel Solver and state the optimal cost.

Answer;

Variables:

Amount of removal pollutants from river A is X1 kg;

Amount of removal pollutants from river B is X2 kg;

Amount of removal pollutants from river C is X3 kg;

Amount of removal pollutants from City is X4 kg;

Amount of removal pollutants from Airport is X5 kg;

Objective:

Minimize cost: $\mathrm{Z} = 35 \times \mathrm{X}_1 + 46 \times X_2 + 50 \times X_3 + 87 \times X_4 + 76 \times X_5$

S.T.

$\mathrm{X}_1 + X_2 + X_3 + X_4 + X_5 \geq 62000$

$23400 \geq \mathrm{X}_1 \geq \frac{23400}{4} = 5850$

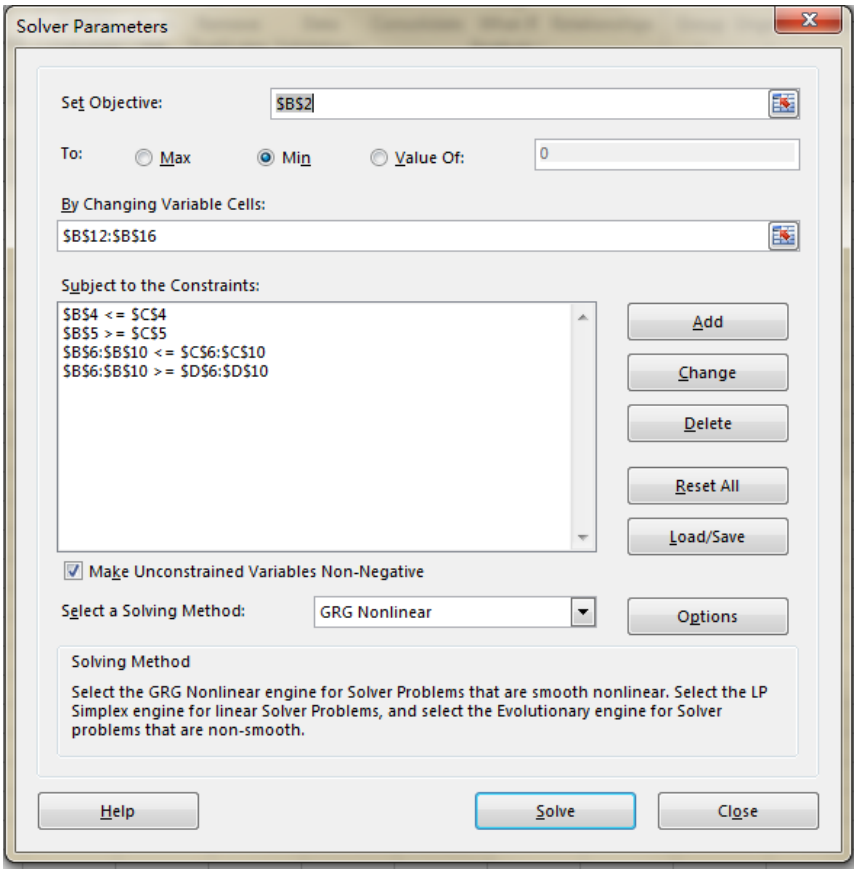
$12800 \geq \mathrm{X}_2 \geq \frac{12800}{4} = 3200$

$28600 \geq \mathrm{X}_3 \geq \frac{28600}{4} = 7150$

$17400 \geq \mathrm{X}_4 \geq \frac{17400}{2} = 8700$

$19400 \geq \mathrm{X}_5 \geq \frac{19400}{4} = 9700$

Solver:



Result:

obj	
Z=35×X_1+46×X_2+50×X_3+87×X_4+76×X_5	3271900

variable	
X_1	23400
X_2	12800
X_3	7400
X_4	8700
X_5	9700

The airport manager would like to invest in a deicing fluid system able to recycle 50% of the pollutants produced by the airport. The new plant is expected to cost $14,000,000 and has a nominal life cycle of at least 15 years.

b) Using principles of engineering economics and Excel, calculate the yearly payments from the airport authority to a bank to buy the recycling system and pay it off at the end of 15 years. Assume the bank charges 4% yearly over the loan period.

Answer:

Total loan	14000000	USD
Period	15	years
APR	4%	
Yearly Pa	($1,210,745.58)	

c) Assume that city in question increases in population at a rate of 2% per year. Assume the pollution increases proportionally to population. How much pollution does the city needs to remove after 15 years?

Answer:

$$P_{15} = P_0 \times (1 + 0.02)^{15}$$

Source	Removal Cost ($/kg)	Pollution to Lake (kg)	Annual Increased Rate	Year	15 Year Polution
River A	35	23,400	0.02	15	31493.31912
River B	46	12,800	0.02	15	17227.11473
River C	50	28,600	0.02	15	38491.83448
City	87	17,400	0.02	15	23418.10909
Airport	76	19,400	0.02	15	26109.84576

Problem 4

A group of engineers in your company setups the following Linear Programming problem to minimize the cost of producing three types of steel beams commonly used in buildings. The objective function is the profit for the company (in dollars per production batch). The company would like to maximize the profit in solving this problem.

Objective Maximize $Z = 150\ X_1 + 200\ X_2 + 210\ X_3$

Subject to

$1.1\ X_1 + 1.2\ X_2 + 1.8\ X_3 <= 2400$

$0.6\ X_1 + 0.7\ X_3 <= 700$

$X_2 - 0.9\ X_3 <= 1300$

$1.4\ X_1 + 2\ X_2 + 2.8\ X_3 >= 3700$

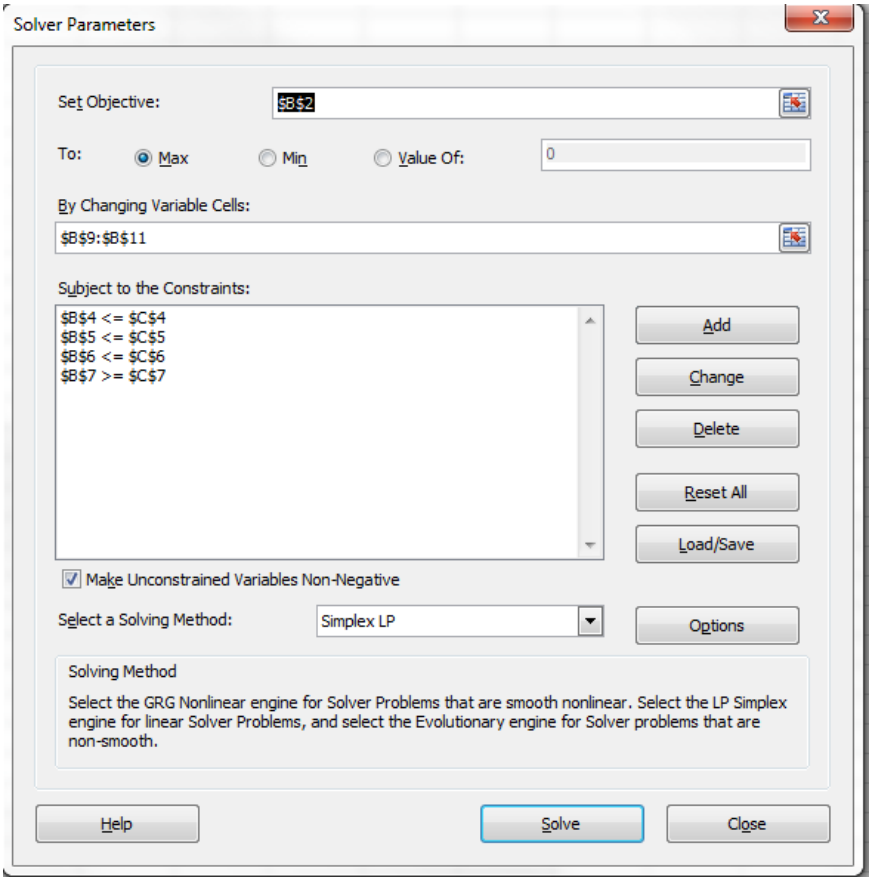
X_1, X_2 and $X_3 >= 0$ (non-negativity conditions)

For each task below, use screen captures of your setup using Excel Solver. Show the formulas of the cells to make out task simpler in grading.

Task 1

Solve the problem using Excel Solver. State the exact solution found by Excel for all three decision variables. State the value of the objective function for the optimal solution found.

Answer:



obj		
Z=150X1+200X2+210X3	374455.25	
s.t.		
1.1X1+1.2X2+1.8X3	2400	2400
0.6 X1 + 0.7 X3	429.37743	700
X2 - 0.9 X3	1300	1300
1.4 X1 + 2 X2 + 2.8 X3	3700	3700
variable		
X1	677.0428	
X2	1329.7665	
X3	33.07393	

Three decision variables:

X1	677.0428
X2	1329.7665
X3	33.07393

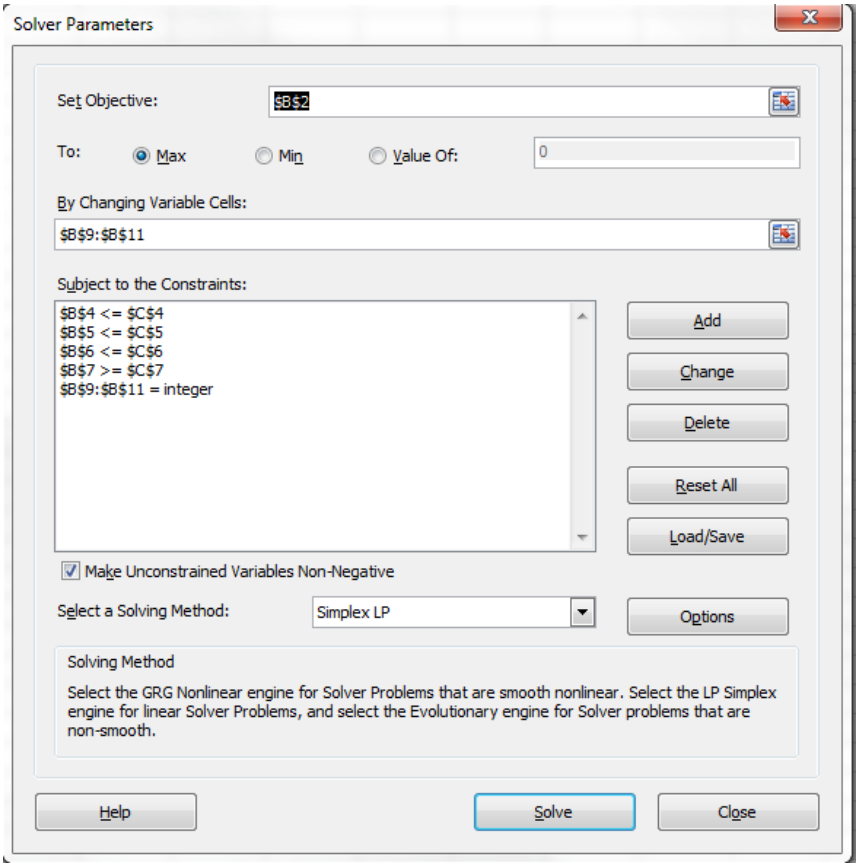
The value of the objective function: 374455.25

Z=150X1+200X2+210X3	374455.25

Task 2

Since number of beams to be produced needs to be an integer solution, solve the problem with Excel to obtain an integer solution. State the value of the objective function for the optimal solution found.

Answer:



obj		
Z=150X1+200X2+210X3	374380	
s.t.		
1.1X1+1.2X2+1.8X3	2400	2400
0.6 X1 + 0.7 X3	407.8	700
X2 - 0.9 X3	1299.8	1300
1.4 X1 + 2 X2 + 2.8 X3	3723.2	3700
variable		
X1	612	
X2	1352	
X3	58	

The value of the objective function: 374380

Task 3

Examine the final integer solution and state which constraint(s) are limiting the solution to the problem. This means which constrains bound the solution of the problem.

Answer:

The constraints showed below are limiting the solution.

$$1.1\ X_1 + 1.2\ X_2 + 1.8\ X_3 <= 2400$$

$$X_2 - 0.9X_3 <= 1300$$