Q1

Decision Variables:

P_{ij} is the number of units of generator i used in year j, where I is from 1 to 4 (10MW,25MW,50MW,100MW)and j is from 1 to 5

P_{1j} refers to the units 10MW generator used in the year j^{th} year , where j is 1 to 5
P_{2j} refers to the 25MW generator used in the year j^{th} year , where j is 1 to 5
P_{3j} refers to the 50MW generator used in the year j^{th} year , where j is 1 to 5
P_{4j} refers to the 100MW generator used in the year j^{th} year , where j is 1 to 5

All decision variables are >=0 and integer

LP Formulation:
Minimize $(300P_{11} + 250P_{12} +200P_{13} + 170P_{14} + 145P_{14} + 460P_{21} + 375P_{22} + 350P_{23} + 280P_{24} + 235P_{25} + 670P_{31} + 558P_{32} + 465P_{33} + 380P_{34} + 320P_{35} + 950P_{41} + 790P_{42} + 670P_{43} + 550P_{44} + 460P_{45})$

Subject to:
$P_{ij} >= 0$ where i is from 1 to 4 and j is from 1 to 5

$U_1 = 10P_{11} + 25P_{21} + 50P_{31} + 100P_{41}$ (Sum of Units generated by 10MW, 25MW, 50MW and 100MW in year 1)

$U_2 = 10P_{12} + 25P_{22} + 50p_{32} + 100P_{42} + U_1$ (Sum of Units generated by 10MW, 25MW, 50MW and 100MW in year 2)

$U_3 = 10P_{13} + 25P_{23} + 50P_{33} + 100P_{43} + U_2$ (Sum of Units generated by 10MW, 25MW, 50MW and 100MW in year 3)

$U_4 = 10P_{14} + 25P_{24} + 50P_{34} + 100P_{44} + U_3$ (Sum of Units generated by 10MW, 25MW, 50MW and 100MW in year 4)

$U_5 = 10P_{15} + 25P_{25} + 50P_{35} + 100P_{45} + U_{4.}$ (Sum of Units generated by 10MW, 25MW, 50MW and 100MW in year 5)

Excess Capacity Required:

$E_1 = R_1 – C = 30$
$E_2 = R_2 – C = 110$
$E_3 = R_1 – C = 200$
$E_4 = R_4 – C = 310$
$E_5 = R_5 – C = 430$

Where C refers to the Current Capacity of 750

$U_1 >= E_1$

$U_2 >= E_2$

$U_3 >= E_3$

$U_4 >= E_4$

$U_5 >= E_5$

Q1 B) Solution Screenshot:

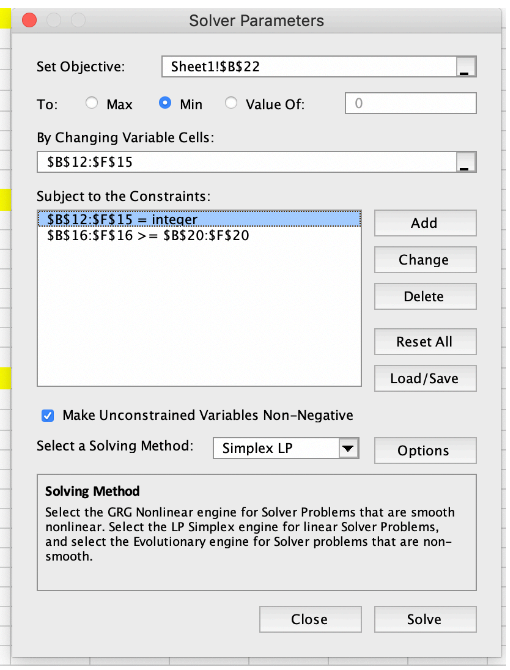
	Cost of Generator in ($1000s) in Year				
Generator Size	1	2	3	4	5
10MW	$300	$250	$200	$170	$145
25MW	$460	$375	$350	$280	$235
50MW	$670	$558	$465	$380	$320
100MW	$950	$790	$670	$550	$460
	Electricity Generted(MW) by Year				
Gen Size/Year	1	2	3	4	5
10	0	1	0	0	0
25	0	0	0	0	1
50	0	0	0	0	0
100	1	0	1	1	1
Units Produced	100	110	210	310	435
Current Capacity	750				
Excess Reqd	30	110	200	310	430
Units Required	780	860	950	1060	1180
cost	3115				

Formula Sheet:

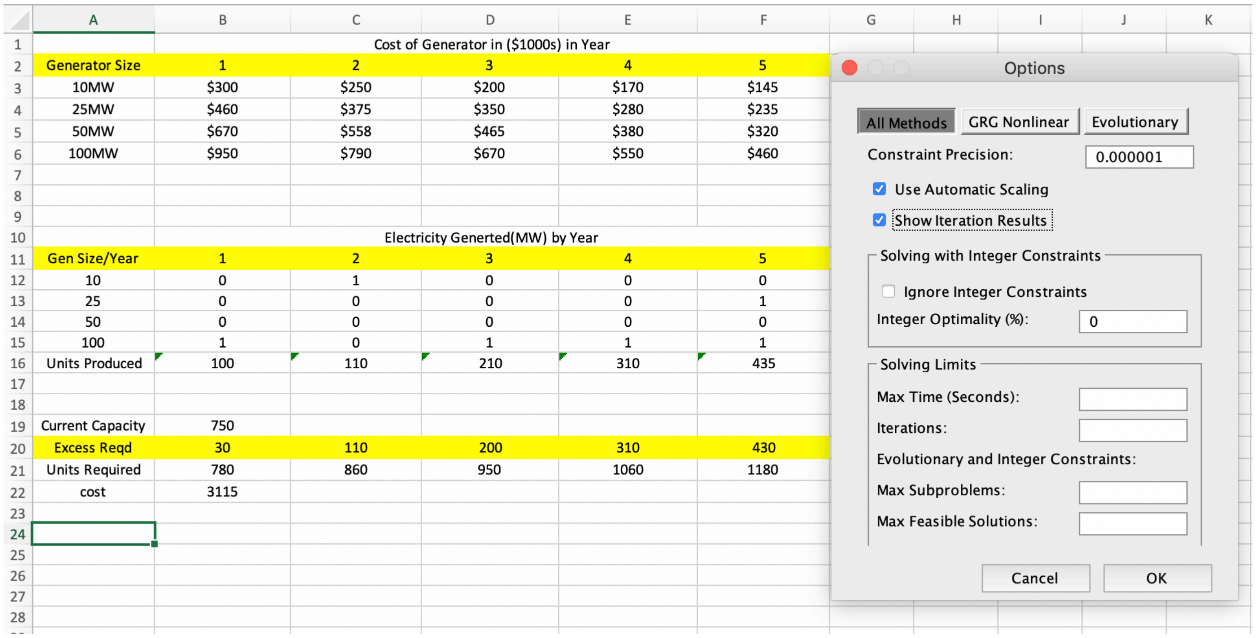
A	B	C	D	E	F
			Cost of Generator in ($1000s) in Year		
Generator Size	1	2	3	4	5
10MW	300	250	200	170	145
25MW	460	375	350	280	235
50MW	670	558	465	380	320
100MW	950	790	670	550	460
			Electricity Generted(MW) by Year		
Gen Size/Year	1	2	3	4	5
10	0	1	0	0	0
25	0	0	0	0	1
50	0	0	0	0	0
100	1	0	1	1	1
Units Produced	=SUMPRODUCT(A12:A15,B12:B15)	=SUMPRODUCT(A12:A15,C12:C15)+B16	=SUMPRODUCT(A12:A15,D12:D15)+C16	=SUMPRODUCT(A12:A15,E12:E15)+D16	=SUMPRODUCT(A12:A15,F12:F15)+E16
Current Capacity	750				
Excess Reqd	=B21-B19	=C21-B19	=D21-B19	=E21-B19	=F21-B19
Units Required	780	860	950	1060	1180
cost	=SUMPRODUCT(B3:F6,B12:F15)				

Solver Solution:

Generator Size	1	2	3	4	5
10MW	$300	$250	$200	$170	$145
25MW	$460	$375	$350	$280	$235
50MW	$670	$558	$465	$380	$320
100MW	$950	$790	$670	$550	$460
			Electricity Generted(MW) by Year		
Gen Size/Year	1	2	3	4	5
10	0	1	0	0	0
25	0	0	0	0	1
50	0	0	0	0	0
100	1	0	1	1	1
Units Produced	100	110	210	310	435
Current Capacity	750				
Excess Reqd	30	110	200	310	430
Units Required	780	860	950	1060	1180
cost	3115				



Solver Screenshot:



	Cost of Generator in ($1000s) in Year				
Generator Size	1	2	3	4	5
10MW	$300	$250	$200	$170	$145
25MW	$460	$375	$350	$280	$235
50MW	$670	$558	$465	$380	$320
100MW	$950	$790	$670	$550	$460
	Electricity Generted(MW) by Year				
Gen Size/Year	1	2	3	4	5
10	0	1	0	0	0
25	0	0	0	0	1
50	0	0	0	0	0
100	1	0	1	1	1
Units Produced	100	110	210	310	435
Current Capacity	750				
Excess Reqd	30	110	200	310	430
Units Required	780	860	950	1060	1180
cost	3115				

Q1 C)
Optimal Solution :

X12 = 1 use 10MW generator in year 2
X25 = 1 use 25MW generator in year 5
X41 = 1 use 100MW generator in year 1
X42 = 1 use 100MW generator in year 2
X43 = 1 use 100MW generator in year 3
X44 = 1 use 100MW generator in year 4
X45 = 1 use 100MW generator in year 5

The minimized Cost to use the generators in the years is: $3,115,000

Q2
Decision Variables:

X_{ij} is the amount of bushels transported from the ith grove to the transportation unit j

LP Formulation:
Minimize $X_{11} + X_{12} + X_{13} + X_{21} + X_{22} + X_{23} + X_{31} + X_{32} + X_{33}$
Y_{ij} refer to the decision corresponding to transporting bushels from i^{th} grove to the j^{th} transportation unit
Subject to :

$X_{11} + X_{12} + X_{13} = 275$
$X_{21} + X_{22} + X_{23} = 400$
$X_{31} + X_{32} + X_{33} = 300$
$X_{11} + X_{21} + X_{31} <= 200$
$X_{12} + X_{22} + X_{32} <= 600$
$X_{13} + X_{23} + X_{33} <= 225$
X11 – MIN(275,200)Y11 <= 0
X12 – MIN275,600)Y12 <= 0
X13 – MIN275,225)Y13 <= 0
X21 - MIN(400,200)Y21 <= 0
X22 - MIN(400,600)Y22 <= 0
X23 - MIN(400,225)Y23 <= 0
X31 - MIN(300,200)Y31 <= 0
X32 - MIN(300,600)Y32 <= 0
X33 - MIN(300,225)Y33 <= 0
Where $X_{ij} >= 0$

Q2 B)
Solution Screenshot:

	A	B	C	D	E	F	G	H
1		Distance Processing Plants						
2	Grove	Ocala	Orlando	Leesburg				
3	Mt Dora	21	50	40				
4	Eustis	35	30	22				
5	Clermont	55	20	25				
6								
7								
8		Cost Distance Processing Plants						
9	Grove	Ocala	Orlando	Leesburg				
10	Mt Dora	168	400	320				
11	Eustis	280	240	176				
12	Clermont	440	160	200				
13								
14		Units to Send						
15	Grove	Ocala	Orlando	Leesburg	Units Sent	Units Available		
16	Mt Dora	0	275	0	275	275		
17	Eustis	175	0	225	400	400		
18	Clermont	0	300	0	300	300		
19	Units Received	175	575	225				
20	Units Required	200	600	225				
21								
22		Path Taken						
23	Grove	Ocala	Orlando	Leesburg				
24	Mt Dora	0	1	0				
25	Eustis	1	0	1				
26	Clermont	0	1	0				
27								
28		Linking Constraint						
29	Grove	Ocala	Orlando	Leesburg		Cost	1016	
30	Mt Dora	0	0	0				
31	Eustis	-25	0	0				
32	Clermont	0	0	0				
33								

Formula Screenshot:

	A	B	C	D	E	F	G
1			Distance Processing Plants				
2	Grove	Ocala	Orlando	Leesburg			
3	Mt Dora	21	50	40			
4	Eustis	35	30	22			
5	Clermont	55	20	25			
6							
7							
8			Cost Distance Processing Plants				
9	Grove	Ocala	Orlando	Leesburg			
10	Mt Dora	=21*8	=50 * 8	=40*8			
11	Eustis	=35*8	=30*8	=22*8			
12	Clermont	=55*8	=20*8	=25*8			
13							
14			Units to Send				
15	Grove	Ocala	Orlando	Leesburg	Units Sent	Units Available	
16	Mt Dora	0	275	0	=SUM(B16:D16)	275	
17	Eustis	175	0	225	=SUM(B17:D17)	400	
18	Clermont	0	300	0	=SUM(B18:D18)	300	
19	Units Received	=SUM(B16:B18)	=SUM(C16:C18)	=SUM(D16:D18)			
20	Units Required	200	600	225			
21							
22			Path Taken				
23	Grove	Ocala	Orlando	Leesburg			
24	Mt Dora	0	1	0			
25	Eustis	1	0	1			
26	Clermont	0	1	0			
27							
28			Linking Constraint				
29	Grove	Ocala	Orlando	Leesburg		Cost	=SUMPRODUCT(B10:D12,B24:D26)
30	Mt Dora	=B16-MIN($F$16,B20)*B24	=C16-MIN($F$16,C20)*C24	=D16-MIN($F$16,D20)*D24			
31	Eustis	=B17-MIN($F$17,B20)*B25	=C17-MIN($F$17,C20)*C25	=D17-MIN($F$17,D20)*D25			
32	Clermont	=B18-MIN($F$18,B20)*B26	=C18-MIN($F$18,C20)*C26	=D18-MIN($F$18,D20)*D26			

Solver Screenshot:

	A	B	C	D	E	F	G
1			Distance Processing Plants				
2	Grove	Ocala	Orlando	Leesburg			
3	Mt Dora	21	50	40			
4	Eustis	35	30	22			
5	Clermont	55	20	25			
6							
7							
8			Cost Distance Processing Plants				
9	Grove	Ocala	Orlando	Leesburg			
10	Mt Dora	168	400	320			
11	Eustis	280	240	176			
12	Clermont	440	160	200			
13							
14			Units to Send				
15	Grove	Ocala	Orlando	Leesburg	Units Sent	Units Available	
16	Mt Dora	0	275	0	275	275	
17	Eustis	175	0	225	400	400	
18	Clermont	0	300	0	300	300	
19	Units Received	175	575	225			
20	Units Required	200	600	225			
21							
22			Path Taken				
23	Grove	Ocala	Orlando	Leesburg			
24	Mt Dora	0	1	0			
25	Eustis	1	0	1			
26	Clermont	0	1	0			
27							
28			Linking Constraint				
29	Grove	Ocala	Orlando	Leesburg		Cost	1016
30	Mt Dora	0	0	0			
31	Eustis	-25	0	0			
32	Clermont	0	0	0			
33							

Solver Parameters

Set Objective: Sheet2!$G$29

To: Max ● Min Value Of: 0

By Changing Variable Cells: $B$16:$D$18,$B$24:$D$26

Subject to the Constraints:

$B$16:$D$18 = integer
$B$16:$D$18 >= 0
$B$19:$D$19 <= $B$20:$D$20
$B$24:$D$26 = binary
$B$30:$D$32 <= 0
$E$16:$E$18 = $F$16:$F$18

Add | Change | Delete | Reset All | Load/Save

☑ Make Unconstrained Variables Non-Negative

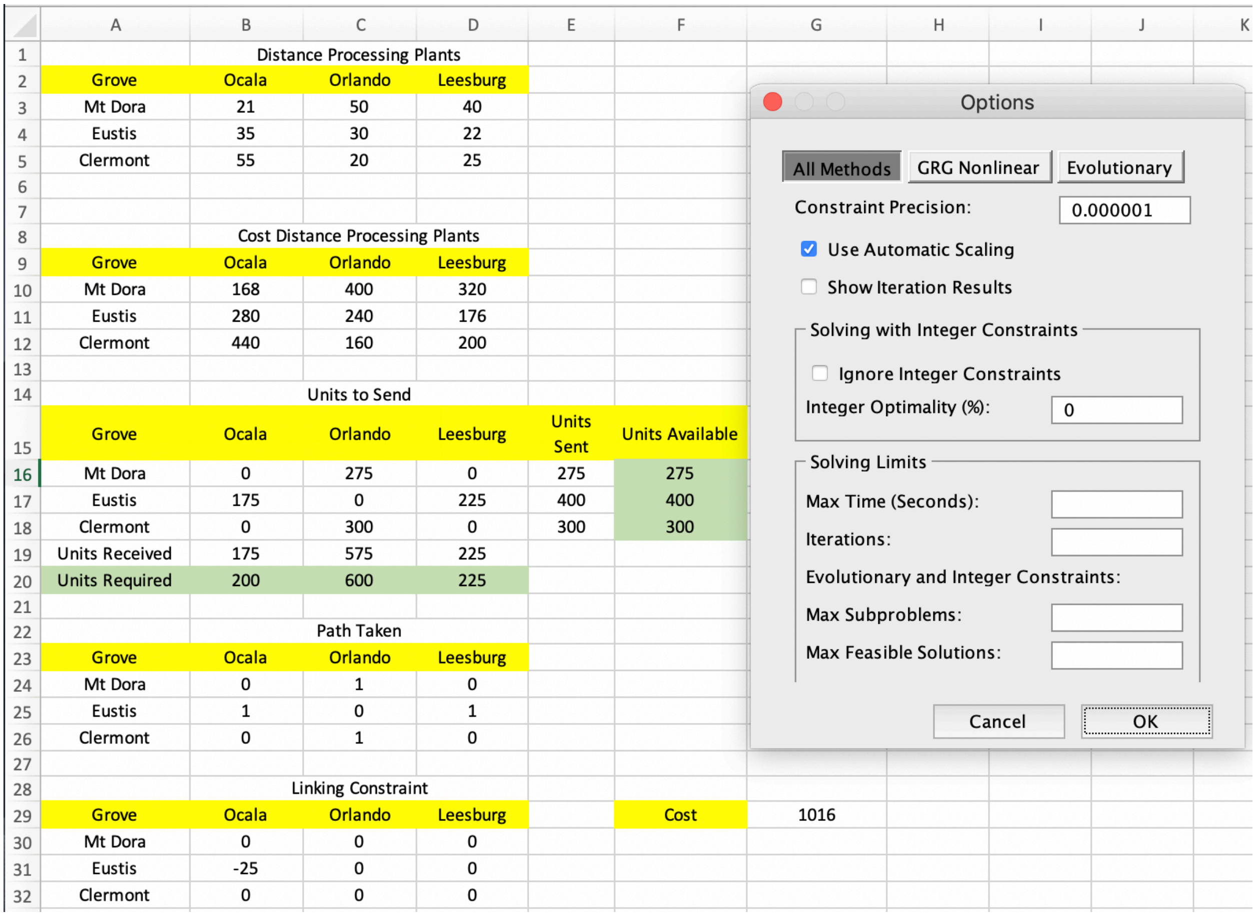
Select a Solving Method: Simplex LP | Options

Solving Method

Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

Close | Solve

Solver Screenshot:



	A	B	C	D	E	F	G
1			Distance Processing Plants				
2	Grove	Ocala	Orlando	Leesburg			
3	Mt Dora	21	50	40			
4	Eustis	35	30	22			
5	Clermont	55	20	25			
6							
7							
8			Cost Distance Processing Plants				
9	Grove	Ocala	Orlando	Leesburg			
10	Mt Dora	168	400	320			
11	Eustis	280	240	176			
12	Clermont	440	160	200			
13							
14			Units to Send				
15	Grove	Ocala	Orlando	Leesburg	Units Sent	Units Available	
16	Mt Dora	0	275	0	275	275	
17	Eustis	175	0	225	400	400	
18	Clermont	0	300	0	300	300	
19	Units Received	175	575	225			
20	Units Required	200	600	225			
21							
22			Path Taken				
23	Grove	Ocala	Orlando	Leesburg			
24	Mt Dora	0	1	0			
25	Eustis	1	0	1			
26	Clermont	0	1	0			
27							
28			Linking Constraint				
29	Grove	Ocala	Orlando	Leesburg		Cost	1016
30	Mt Dora	0	0	0			
31	Eustis	-25	0	0			
32	Clermont	0	0	0			

Optimal Solution:

X12 = 275 , transfer 275000 bushels from Mt Dora to Orlando
X21 = 175, transfer 175000 bushels from Eustis to Ocala
X23 = 225, transfer 175000 bushels from Eustis to Ocala
X31 = 300, transfer 175000 bushels from Clermont to Orlando

The minimized Cost of transporting the bushels from the groves to the processing plant is : $1016

Q3

Let S1, S2 and S3 be the shortage of the Diesel fuel, Regular Unleaded Gasoline and Premium Unleaded Gasoline in the tanker truck's compartments

Let F_{ij} represent the amount (gallons) of i^{th} fuel transferred loaded into the j^{th} compartment
Let Y_{ij} represent the decision corresponding to loading the i^{th} fuel into the j^{th} compartment
Where i varies from 1 to 3 and j varies from 1 to 5

LP formulation:
Minimize S1+ S2 + S3

Subject To:

F11+ F12 + F13+ F14 + F15 = 2700, This is the demand for Diesel fuel
F21 + F22 + F23 + F24 + F25 = 3500, This is the demand for Regular Gasoline
F31 + F32 + F33 + F34 + F35 = 4200, This is the demand for Premium Gasoline

Y11+ Y21+ Y31 <= 1 (decision corresponding to compartment 1)
Y12 + Y22 + Y32 <= 1 (decision corresponding to compartment 2)
Y13 + Y23 + Y33 <= 1 (decision corresponding to compartment 3)
Y14 + Y24 + Y34 <= 1 (decision corresponding to compartment 4)
Y15 + Y25 + Y36 <= 1 (decision corresponding to compartment 5)

F11 < 2500 * Y11
F12 < 2000 * Y12
F13 < 1500 * Y13
F14 < 1800 * Y14
F15 < 2300 * Y15

F21 < 2500 * Y21
F22 < 2000 * Y22
F23 < 1500 * Y23
F24 < 1800 * Y24
F25 < 2300 * Y25

F31 < 2500 * Y31
F32 < 2000 * Y32
F33 < 1500 * Y33
F34 < 1800 * Y34
F35 < 2300 * Y35

All $F_{ij} >= 0$

All decision variables are >=0 and integer

Y_{ij} = 1 , if fuel i is loaded in j^{th} compartment
Y_{ij} = 0, if fuel i is **NOT** loaded in j^{th} compartment

Q3 B)

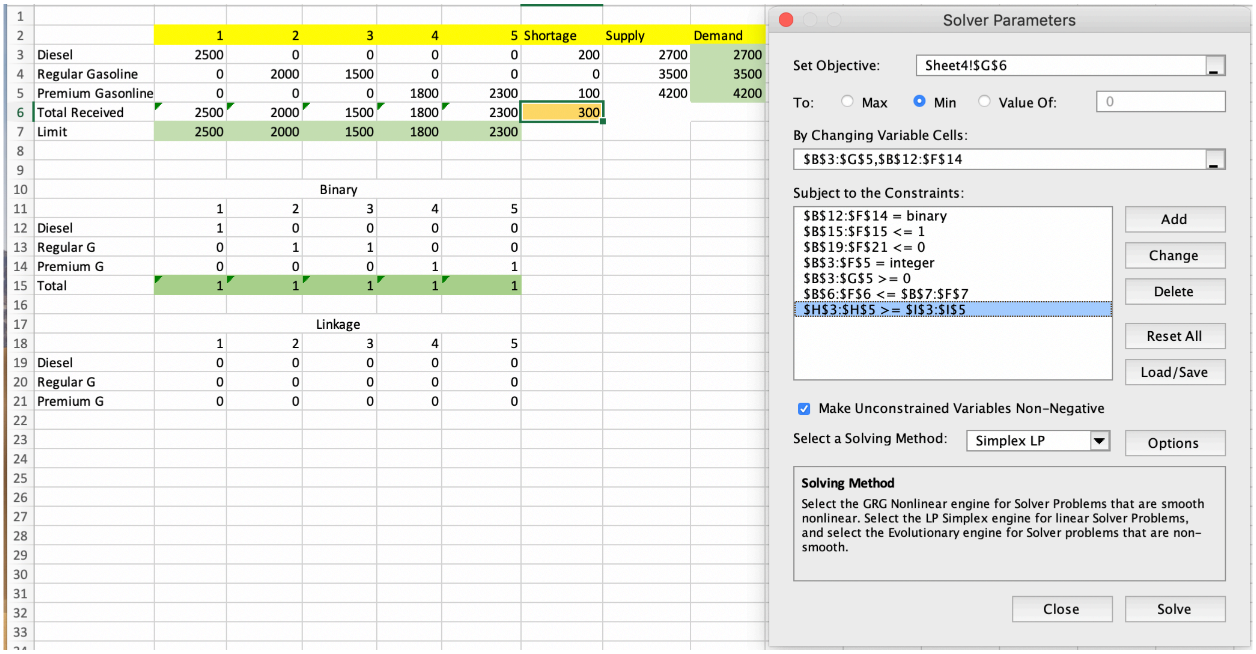
Solution Screenshot:

	A	B	C	D	E	F	G	H	I
1									
2		1	2	3	4	5	Shortage	Supply	Demand
3	Diesel	2500	0	0	0	0	200	2700	2700
4	Regular Gasoline	0	2000	1500	0	0	0	3500	3500
5	Premium Gasonline	0	0	0	1800	2300	100	4200	4200
6	Total Received	2500	2000	1500	1800	2300	300		
7	Limit	2500	2000	1500	1800	2300			
8									
9									
10				Binary					
11		1	2	3	4	5			
12	Diesel	1	0	0	0	0			
13	Regular G	0	1	1	0	0			
14	Premium G	0	0	0	1	1			
15	Total	1	1	1	1	1			
16									
17				Linkage					
18		1	2	3	4	5			
19	Diesel	0	0	0	0	0			
20	Regular G	0	0	0	0	0			
21	Premium G	0	0	0	0	0			
22									

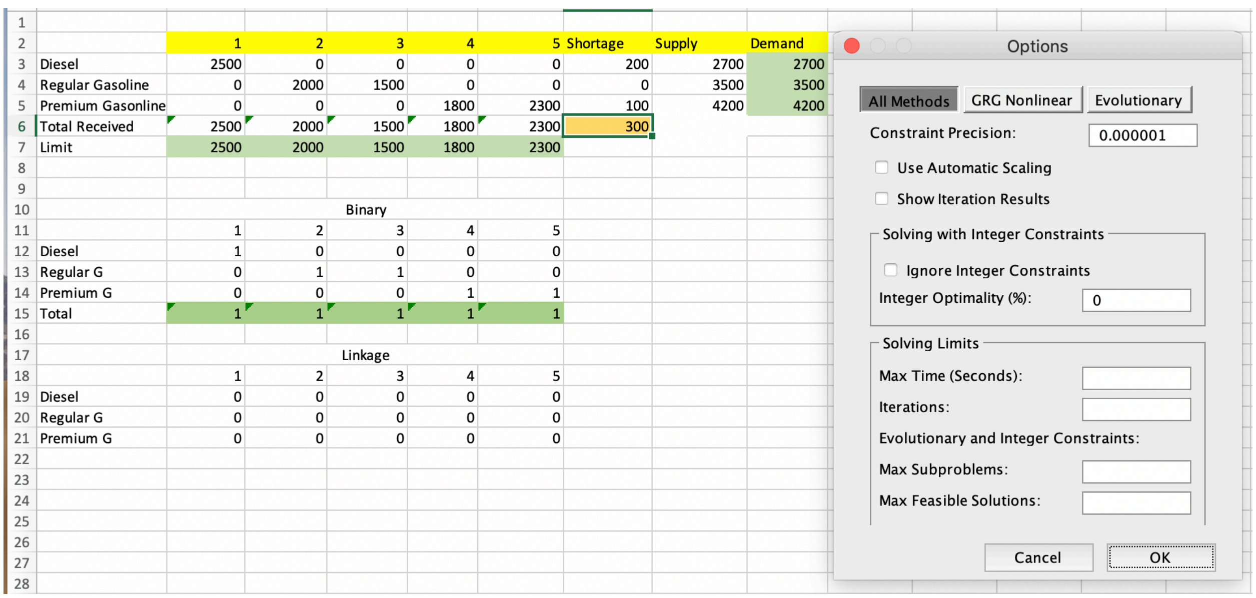
Formula Screenshot:

1									
2		1	2	3	4	5	Shortage	Supply	Demand
3	Diesel	2500	0	0	0	0	200	=SUM(B3:G3)	2700
4	Regular Gasoline	0	2000	1500	0	0	0	=SUM(B4:G4)	3500
5	Premium Gasonline	0	0	0	1800	2300	100	=SUM(B5:G5)	4200
6	Total Received	=SUM(B3:B5)	=SUM(C3:C5)	=SUM(D3:D5)	=SUM(E3:E5)	=SUM(F3:F5)	=SUM(G3:G5)		
7	Limit	2500	2000	1500	1800	2300			
8									
9									
10				Binary					
11		1	2	3	4	5			
12	Diesel	1	0	0	0	0			
13	Regular G	0	1	1	0	0			
14	Premium G	0	0	0	1	1			
15	Total	=SUM(B12:B14)	=SUM(C12:C14)	=SUM(D12:D14)	=SUM(E12:E14)	=SUM(F12:F14)			
16									
17				Linkage					
18		1	2	3	4	5			
19	Diesel	=B3-B7*B12	=C3-C7*C12	=D3-D7*D12	=E3-E7*E12	=F3-F7*F12			
20	Regular G	=B4-B7*B13	=C4-C7*C13	=D4-D7*D13	=E4-E7*E13	=F4-F7*F13			
21	Premium G	=B5-B7*B14	=C5-C7*C14	=D5-D7*D14	=E5-E7*E14	=F5-F7*F14			
22									
23									

Solver Screenshot:



Solver Screenshot:



Q3 C) Optimal Solution:

F11 = 2500, transfer 2500 gallons of Diesel into compartment 1
F22 = 2000, transfer 2000 gallons of Regular unleaded Gasoline into compartment 2
F23 = 1500, transfer 1500 gallons of Regular unleaded Gasoline into compartment 3
F34 = 1800, transfer 1800 gallons of Premium unleaded Gasoline into compartment 4
F35 = 2300, transfer 2300 gallons of Premium unleaded Gasoline into compartment 5

The minimized Shortage of the three types of fuel is 300 gallons

Q4.
Decision Variables

X1 : # of AQs to build in stage 1
X2. : # of HLs to build in stage 1
Y1 : # of AQs to build in stage 2, under scenario A
Y1 : # of HLs to build in stage 2, under scenario A
Z1 : # of AQs to build in stage 2, under scenario B
Z2 : # of HLs to build in stage 2, under scenario B
A1 : # of AQs to build in stage 2, under scenario C
A2 : # of HLs to build in stage 2, under scenario C

Objective Function :
Max E(profit)
= 0.3 *(profit under scenario A) + 0.5 *(profit under scenario B) + 0.2 *(profit under scenario C)
= 0.3 * (350(X1 + Y1) +. 300(X2 + Y2)) +
0.5(300 (X1 + Z1) + 350(X2 + Z2))+
0.2 * (300(X1 + A1) + 300(X2 + A2))

Subject To:

(X1 + Y1) + (X2 + Y2) <= 200
9(X1 + Y1) + 6(X2 + Y2) <= 2880
12X1 + 14Y1 + 16X2 + 18Y2 <= 1566

(X1 + Z1) + (X2 + Z2) <= 200
9(X1 + Z1) + 6(X2 + Z2) <= 2880
12X1 + 14Z1 + 16X2 + 18Z2 <= 1566

(X1 + A1) + (X2 + A2) <= 200
9(X1 + A1) + 6(X2 + A2) <= 2880
12X1 + 14A1 + 16X2 + 18A2 <= 1566

All variables >=0