Microsoft Excel

Microsoft Excel

1. Go to the Course Website on BlackBoard
2. In Lectures, right click and save to your desktop “Session 4 Excel 365” (Excel spreadsheet)

References

Examples and additional details are available in recommended textbook:

Microsoft Excel: Data Analysis and Business Modeling, Wayne L. Winston

Microsoft Goal Seek

4.1 Goal Seek

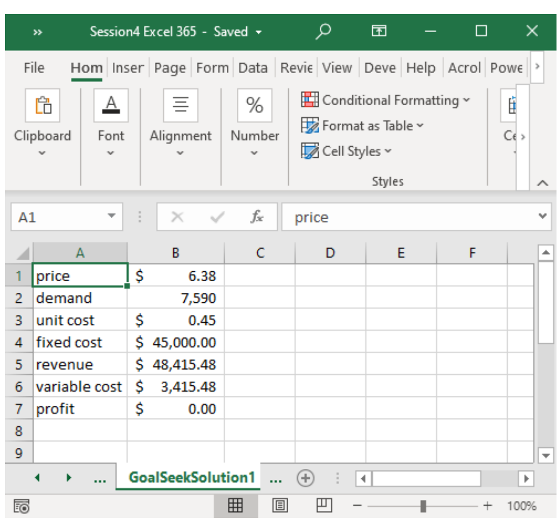
The goal seek command searches for a solution by varying a parameter until a solution is found. Definitions:

Set cell: formula for the answer that you are seeking
To value: value that you want to achieve
By changing cell: the cell that changes until the Set cell matches the To value.

In the example adapted from your book, let’s find the price that results in a breakeven point. In other words, we will vary demand until profit equals zero. Use the spreadsheet tab GoalSeek. The following commands run GoalSeek.

1. Click on the Data tab at the top of the spreadsheet.
2. Click on What-if Analysis, Goal Seek.
3. For Set Cell, enter the cell that is the outcome variable that you want to match. Since we are measuring profit as the outcome, enter $B$7.
4. For the To Value, enter zero, since we are trying to find the break-even point.
5. For the By Changing Cell, enter the cell which will change, in this case price B1.
6. Click OK to find the solution.

You should get the solution shown below.



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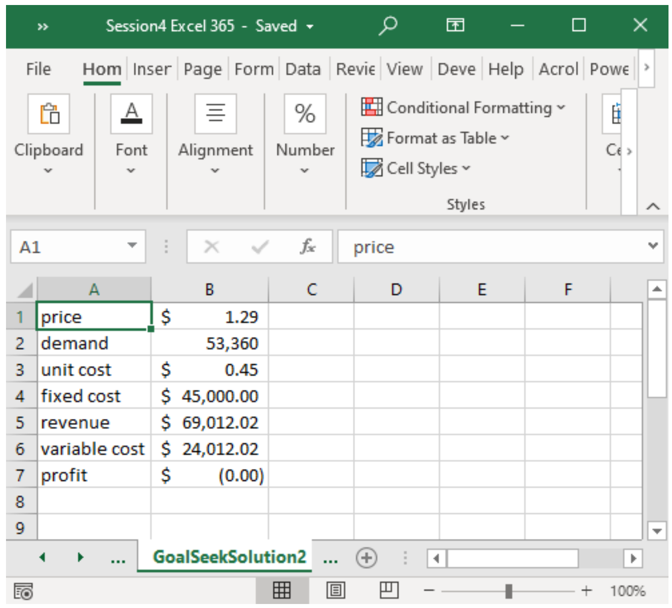
7. Now rerun GoalSeek with a starting price of 0.
8. Click on What-if Analysis, Goal Seek.
9. For Set Cell, enter the cell that is the outcome variable that you want to match. Since we are measuring profit as the outcome, enter $B$7.
10. For the To Value, enter zero, since we are trying to find the break-even point.
11. For the By Changing Cell, enter the cell which will change, in this case price B1.
12. Click OK to find the solution.
13. What's the difference? Why?



14. The profit curve is non-linear with two break-even points

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Microsoft Solver

4.2 Solver Add-in

The Solver option is available as an add-in to Excel. The steps to add it are:

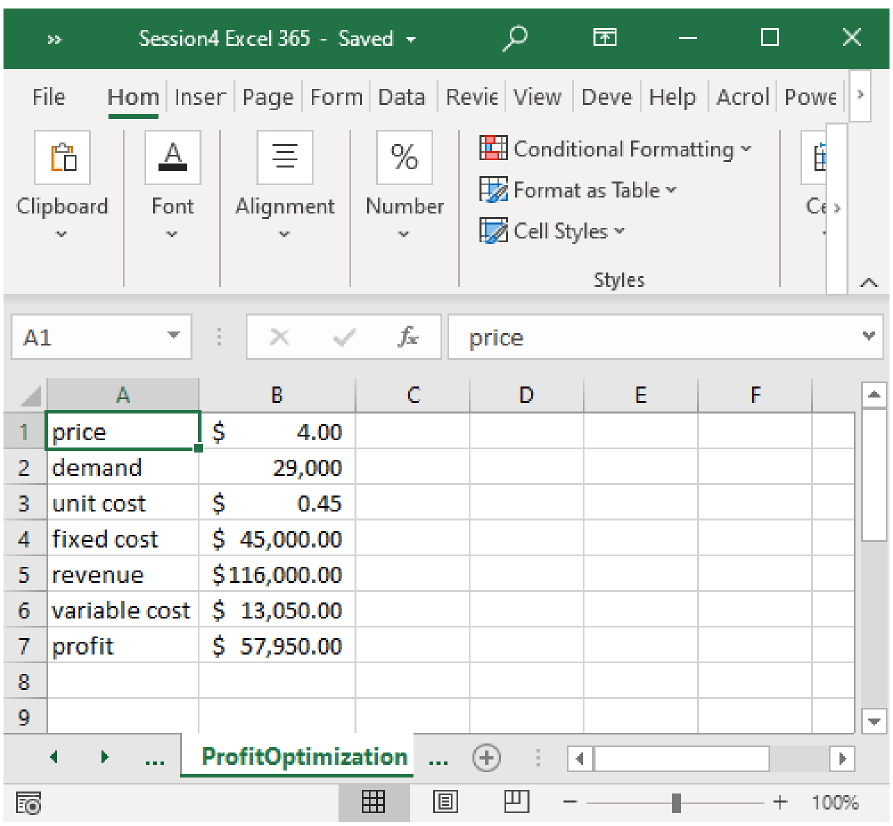
1. In Excel, click on the File tab, then Options
2. Click on Add-Ins
3. Click Analysis Tool Pack Add-in, then Go
4. Check the box for Solver Add-in, then OK

Introduction to solver

Solver has the ability to search for an optimal solution subject to constraint. In contrast, goal seek would search for a solution that would match a specific value, such as demand-supply=0. Solver will find the maximum or minimum of a function, called the optimal feasible solution, if one exists. In some cases, particularly overly constrained problems, there will be no solution.

Simple Optimization

Recall the price-demand function from earlier.



As price increases, demand decreases. Attempt to find the price that maximizes profit by changing the price.

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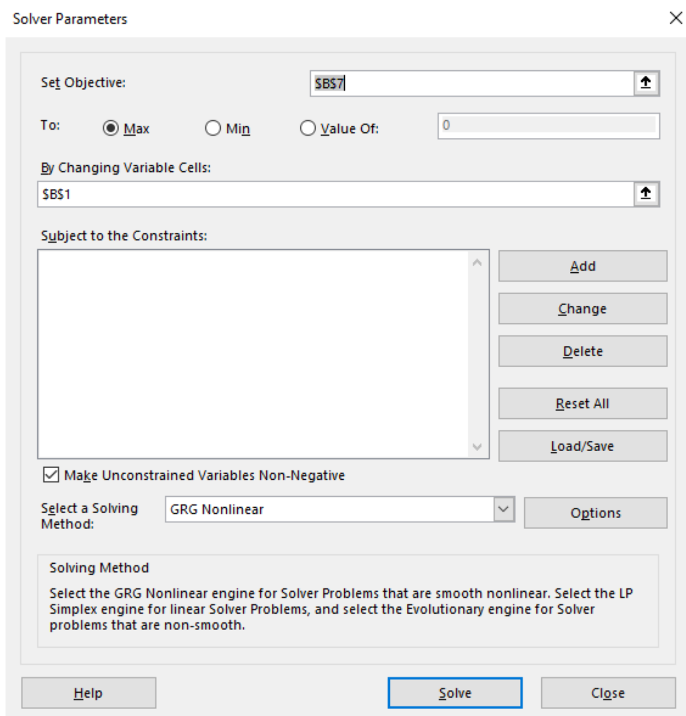
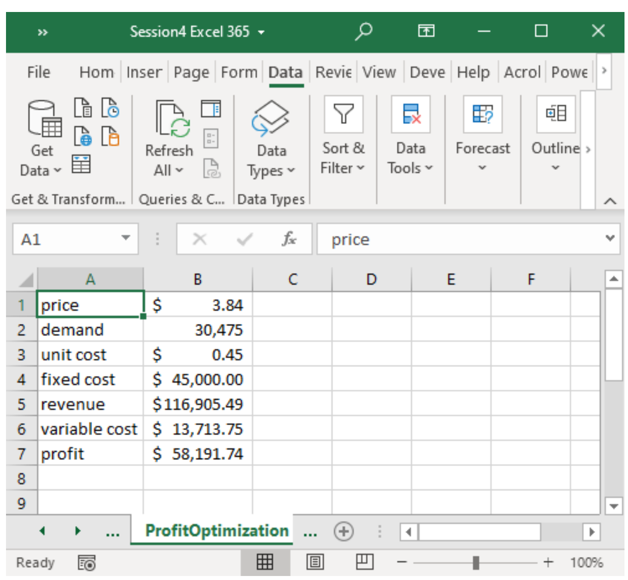
Let’s use Solver to quickly calculate the optimal price.

1. Click on the Data tab, then click on Solver.
2. The Objective is the cell that you want to maximize or minimize. We want to maximize profit, so enter B7 in the objective, and click on Max
3. Since we want to find the price that results in maximum profit, we will change price until we find a solution. In the box labelled “By Changing Variable Cells”, enter B1, which is where price is stored.
4. Now click Solve.



You can keep the solver solutions or restore original values.



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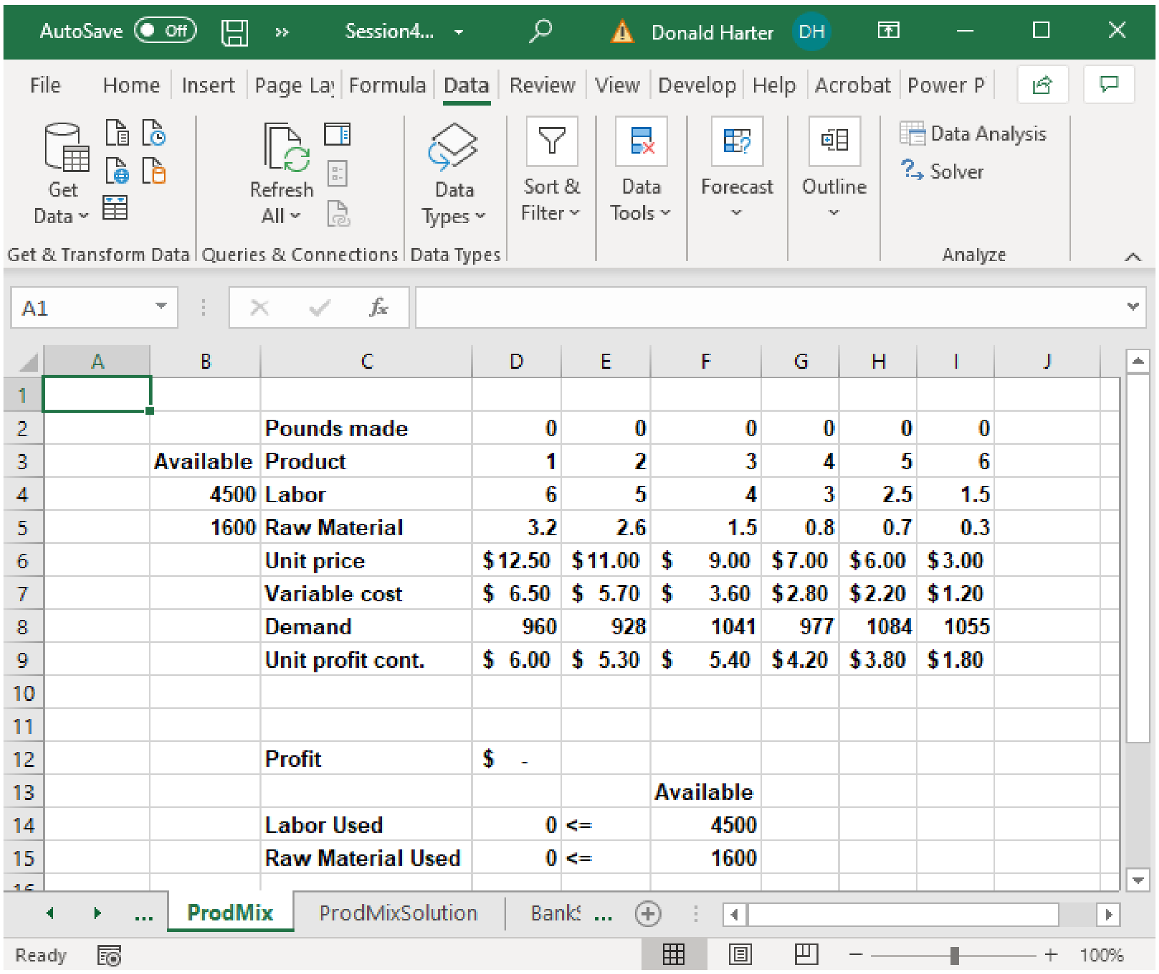
4.3 Useful Functions for Solver

One function that is helpful in setting up optimization problems is the SUMPRODUCT function. SUMPRODUCT first multiplies two columns or rows together (product), then adds the resulting values (sum). In the example below, labor used in cell D14=SUMPRODUCT($D$2:$I$2,D4:I4), which will multiply the values in D2:I2 against the paired value in D4:I4, i.e., D2*D4, E2*E4, etc., then add together the results. How are profit in cell D12 and raw material used in D15 calculated? This concept will be used in each of the following chapters.

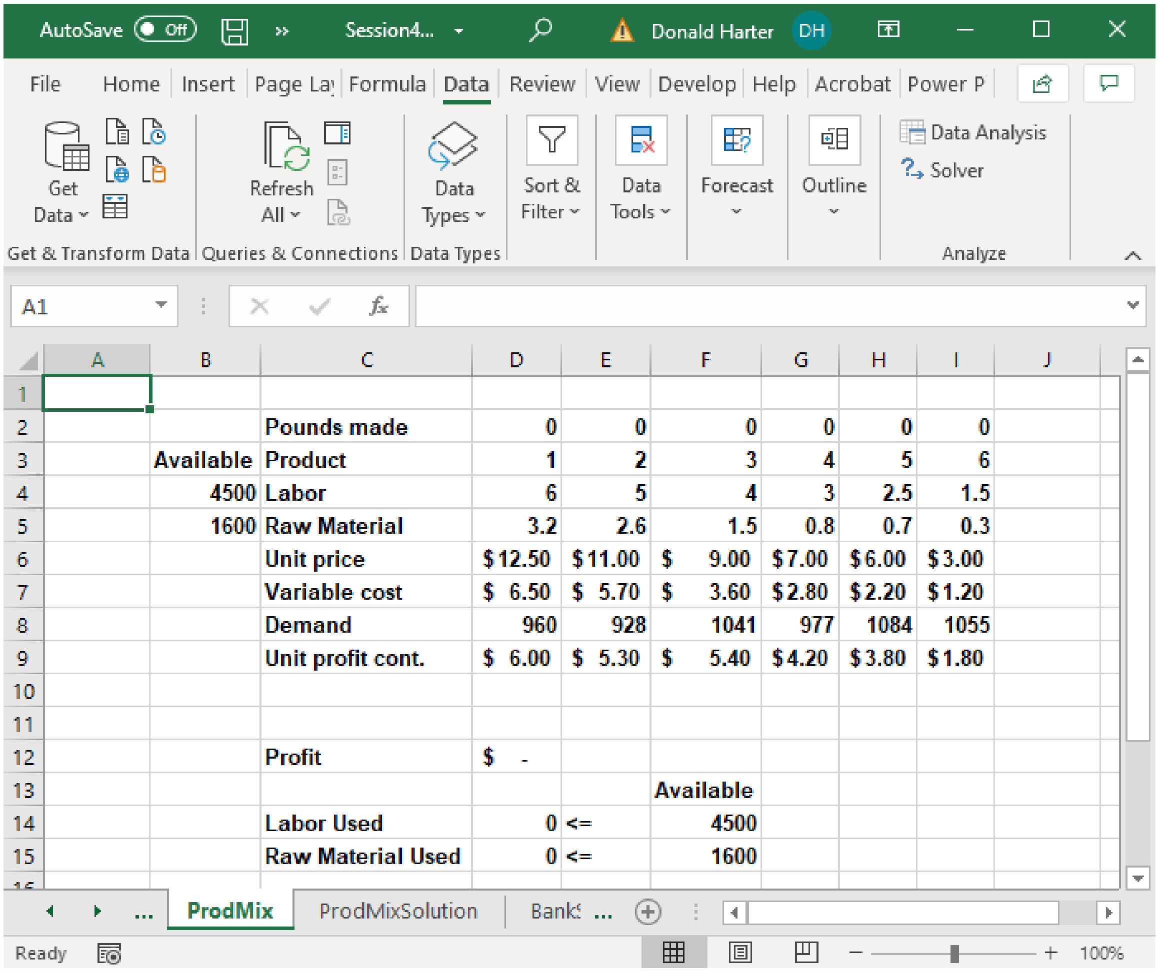
Use the ProdMix spreadsheet to see the example below.



	A	B	C	D	E	F	G	H	I	J
1										
2			Pounds made	0	0	0	0	0	0	
3		Available	Product	1	2	3	4	5	6	
4		4500	Labor	6	5	4	3	2.5	1.5	
5		1600	Raw Material	3.2	2.6	1.5	0.8	0.7	0.3	
6			Unit price	$12.50	$11.00	$ 9.00	$7.00	$6.00	$3.00	
7			Variable cost	$ 6.50	$ 5.70	$ 3.60	$2.80	$2.20	$1.20	
8			Demand	960	928	1041	977	1084	1055	
9			Unit profit cont.	$ 6.00	$ 5.30	$ 5.40	$4.20	$3.80	$1.80	
10										
11										
12			Profit	$ -						
13						Available				
14			Labor Used	0	<=	4500				
15			Raw Material Used	0	<=	1600				

4.4 Optimal product mix

For this problem, use the ProdMix spreadsheet.
In the optimal product mix problem, we are trying to produce six different products, where the labor and raw materials are constrained. The goal is to find the production volumes for each product that maximizes profitability.



	A	B	C	D	E	F	G	H	I	J
1										
2			Pounds made	0	0	0	0	0	0	
3		Available	Product	1	2	3	4	5	6	
4		4500	Labor	6	5	4	3	2.5	1.5	
5		1600	Raw Material	3.2	2.6	1.5	0.8	0.7	0.3	
6			Unit price	$12.50	$11.00	$ 9.00	$7.00	$6.00	$3.00	
7			Variable cost	$ 6.50	$ 5.70	$ 3.60	$2.80	$2.20	$1.20	
8			Demand	960	928	1041	977	1084	1055	
9			Unit profit cont.	$ 6.00	$ 5.30	$ 5.40	$4.20	$3.80	$1.80	
10										
11										
12			Profit	$ -						
13						Available				
14			Labor Used	0	<=	4500				
15			Raw Material Used	0	<=	1600				

The product numbers are listed in row 3, with the labor hours and raw material required to produce one pound of that product in rows 4 and 5. The maximum demand is in row 8. The maximum labor and raw materials available are also identified. Demand, labor and raw materials are constraints.

To use solver, follow these steps:

1. Click on the Data tab
2. In the Analysis group, click Solver.
3. Set Objective to the cell that you want to maximize or minimize. In this case, set it to profit ($D$12)
4. Since we want to maximize profit, make sure the Max button is checked.
5. By Changing Cell refers to what you want to vary. In this case, we want to vary product quantities to find the optimal production quantities. Click in the box and set this to D2:I2. The screen should look like the picture below.

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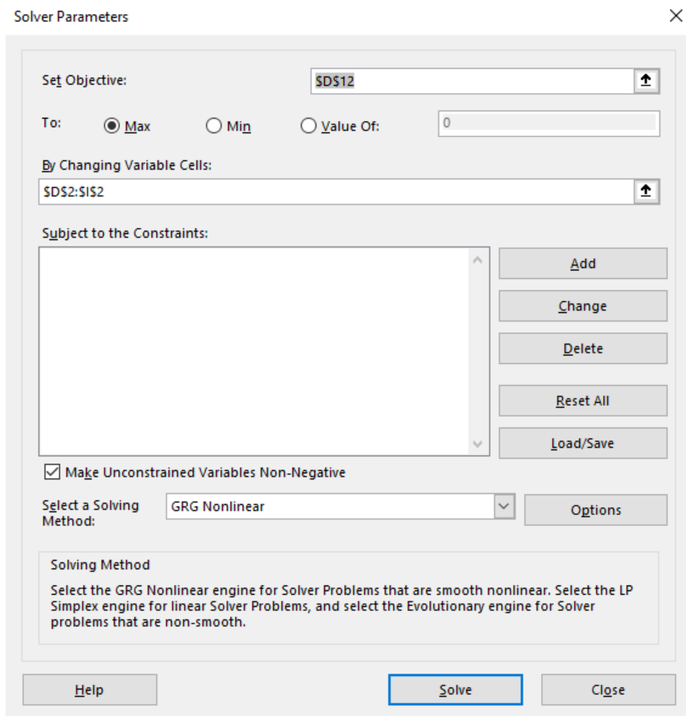
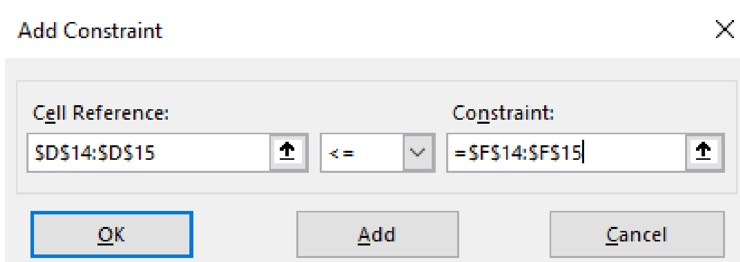
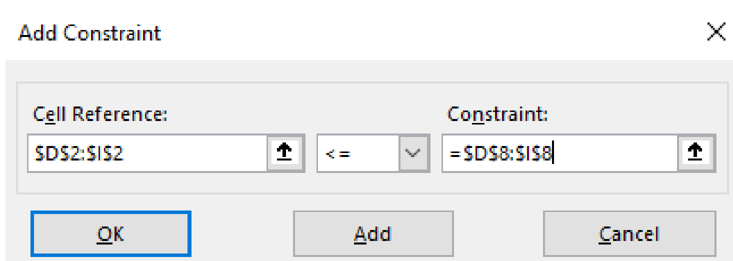


6. Next, add the constraints. First, click the Add button.
7. We want to impose a labor and resource constraint. We can do both simultaneously by entering D14:D15 and F14:F15 as below. Set the constraint direction to <=.
8. Click Add to add another constraint.



9. We also want to make sure that we don't produce more than is demanded. After clicking add in the earlier step, Add Constraint let's you add more constraints. In this case, production (row 2) should not exceed demand (row 8). Set this demand constraint by entering D2:I2 and D8:I8. Set the constraint direction to <=.



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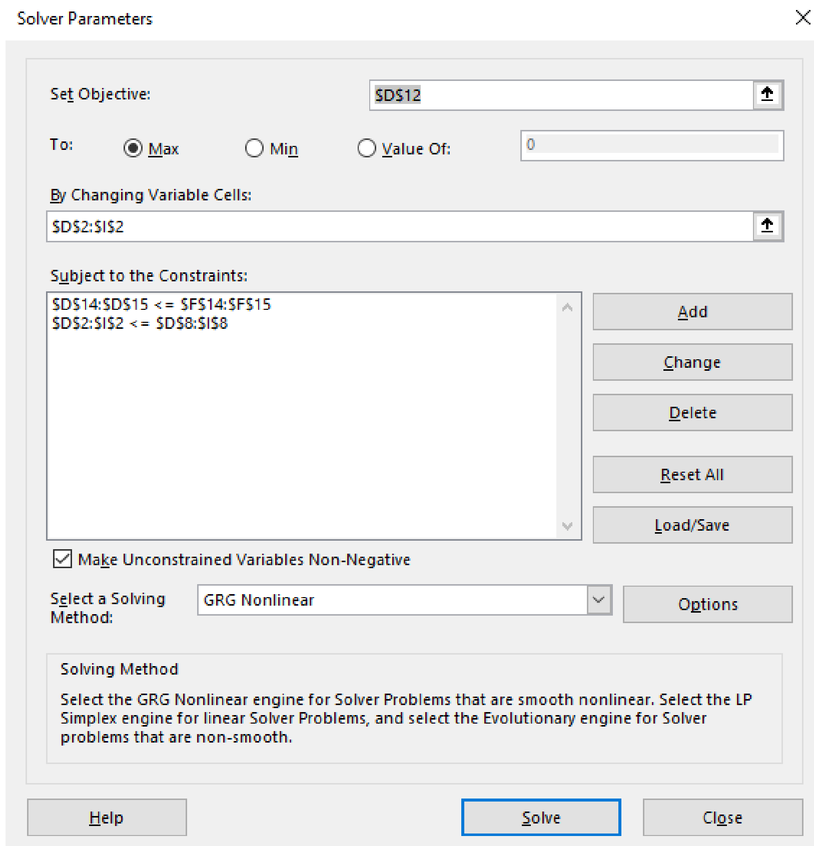
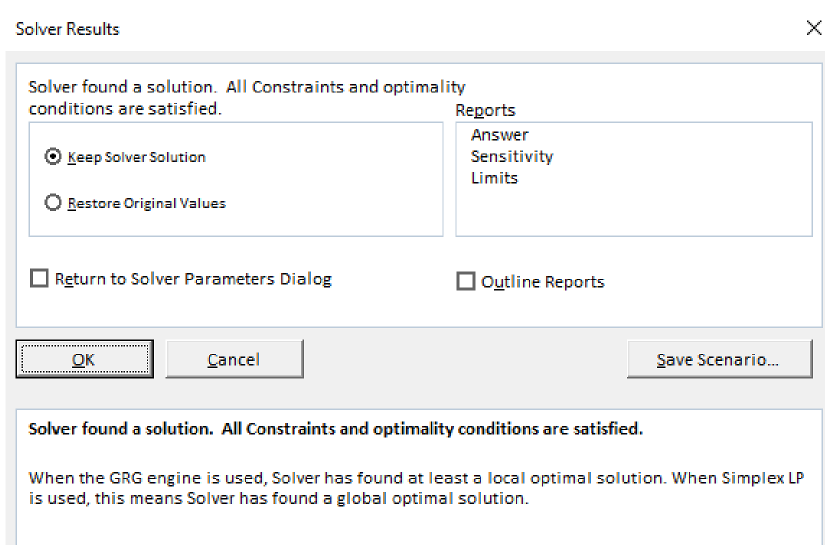
10. Since this is the last constraint, click OK. You should be returned to the following screen.



11. Finally, click on Solve. Select Keep Solver Solution if you want to save your answer. You can select three reports (Answer, Sensitivity, Limits) by clicking on them.



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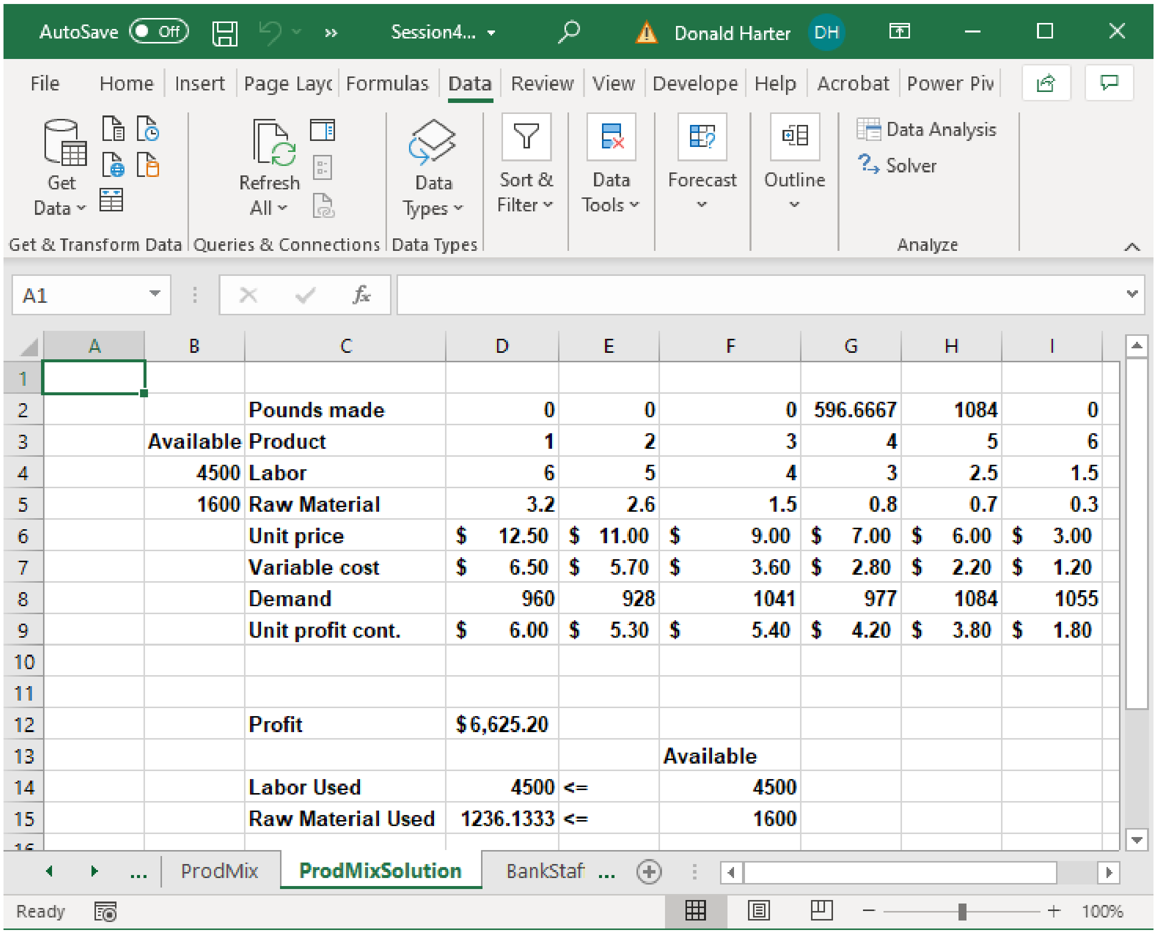
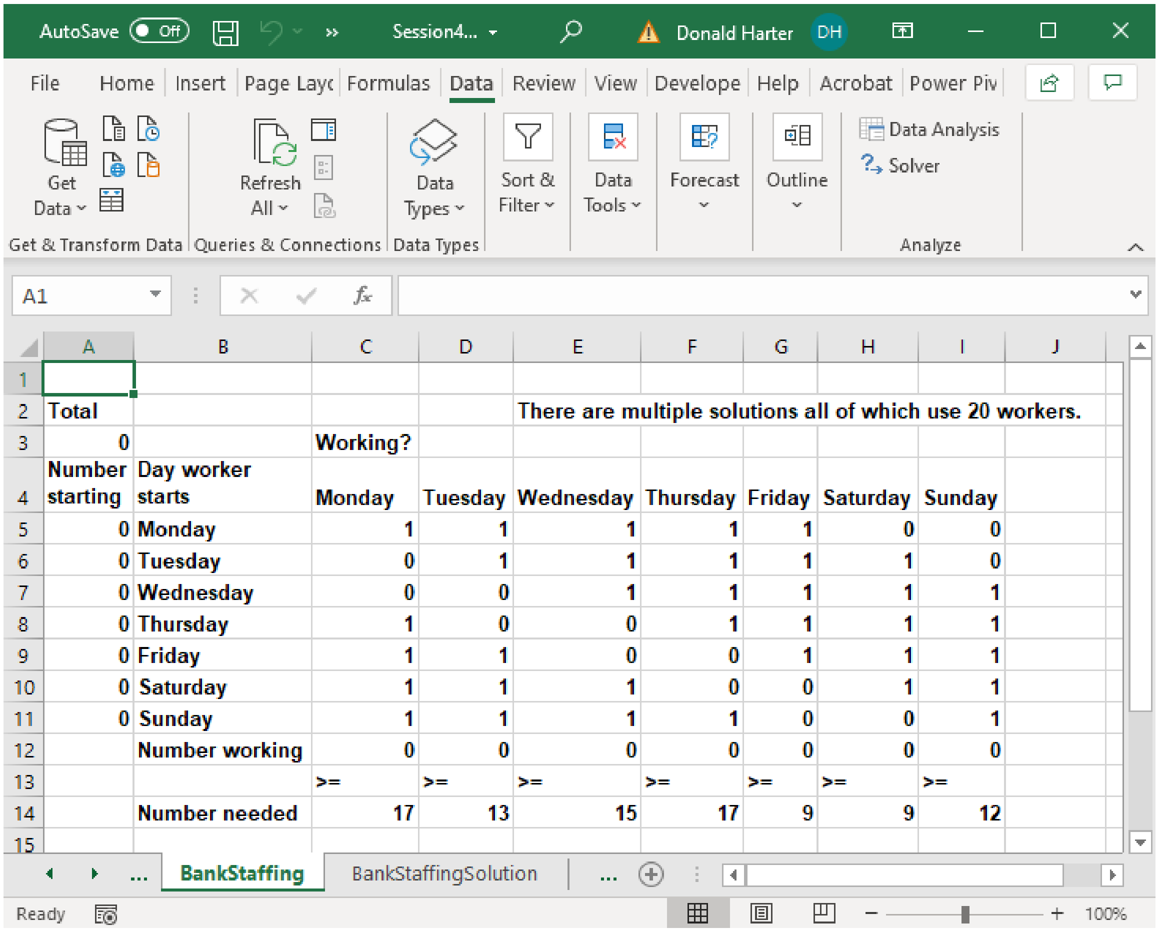
12. When you have made your selections, click OK. You should see the solution shown below. If you clicked on the additional reports, they will be listed as separate tabs.



	A	B	C	D	E	F	G	H	I
1									
2			Pounds made	0	0	0	596.6667	1084	0
3		Available	Product	1	2	3	4	5	6
4		4500	Labor	6	5	4	3	2.5	1.5
5		1600	Raw Material	3.2	2.6	1.5	0.8	0.7	0.3
6			Unit price	$ 12.50	$ 11.00	$ 9.00	$ 7.00	$ 6.00	$ 3.00
7			Variable cost	$ 6.50	$ 5.70	$ 3.60	$ 2.80	$ 2.20	$ 1.20
8			Demand	960	928	1041	977	1084	1055
9			Unit profit cont.	$ 6.00	$ 5.30	$ 5.40	$ 4.20	$ 3.80	$ 1.80
10									
11									
12			Profit	$ 6,625.20					
13						Available			
14			Labor Used	4500	<=	4500			
15			Raw Material Used	1236.1333	<=	1600			

4.5 Schedule workforce

In this example, we are trying to staff a bank with a minimum number of employees by day. The employees can work five consecutive days, starting on any one day. How many employees are needed to work in each shift? Use the Bank Staffing spreadsheet.



	A	B	C	D	E	F	G	H	I	J
1										
2	Total				There are multiple solutions all of which use 20 workers.					
3	0		Working?							
4	Number starting	Day worker starts	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	
5	0	Monday	1	1	1	1	1	0	0	
6	0	Tuesday	0	1	1	1	1	1	0	
7	0	Wednesday	0	0	1	1	1	1	1	
8	0	Thursday	1	0	0	1	1	1	1	
9	0	Friday	1	1	0	0	1	1	1	
10	0	Saturday	1	1	1	0	0	1	1	
11	0	Sunday	1	1	1	1	0	0	1	
12		Number working	0	0	0	0	0	0	0	
13			>=	>=	>=	>=	>=	>=	>=	
14		Number needed	17	13	15	17	9	9	12	
15										

Cells A5:A11 have an initial assignment of people to shifts. Cell A5=1 means that one person will start working on a Monday. The cells C5:I5 show the days worked for a “Monday” shift. To calculate how many people are working each day, the Number working is the sumproduct. Management has determined the minimum number of employees that are required per day, listed as number needed. Now, let’s find a solution. The steps are:

1. Objective: minimize the number of employees
2. Changing cells: number of employees who start work for each shift
3. Constraints: number of employees working must be greater than or equal to the number of employees required.
4. Also, set a constraint that you should have whole people, i.e., people are integer.

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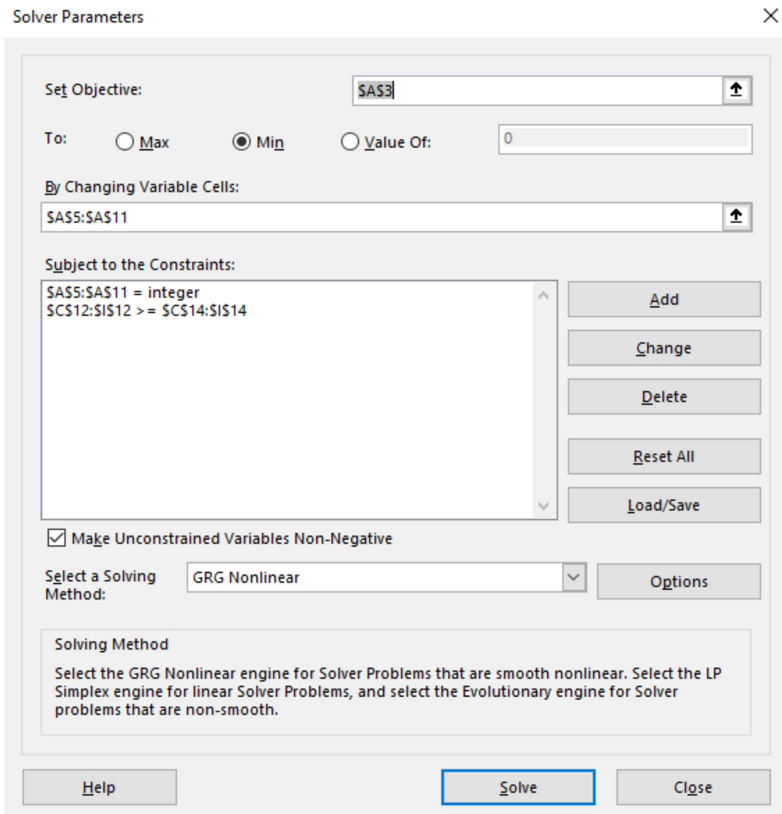
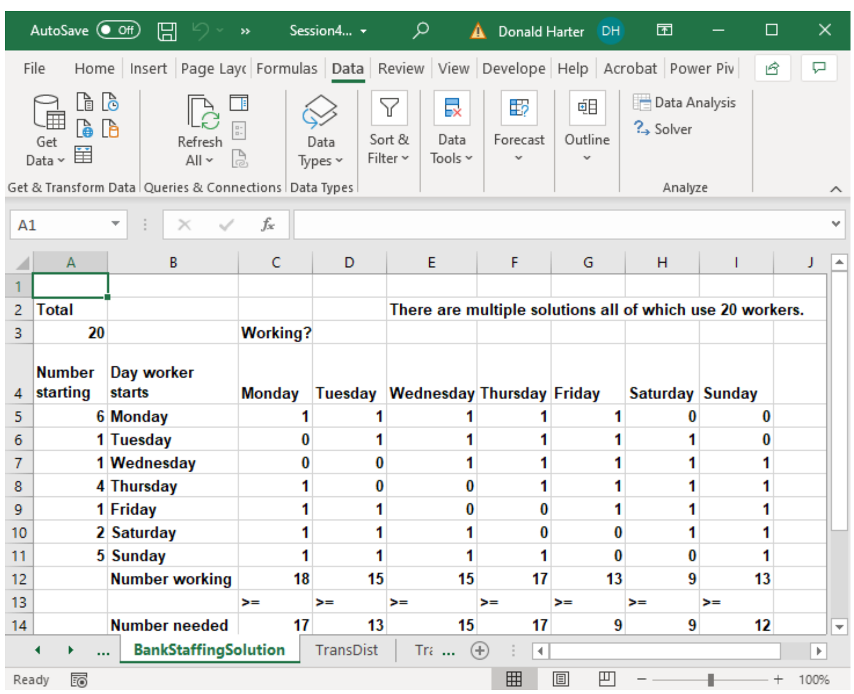


5. Run the solver as before.
6. Click OK to save the solution.



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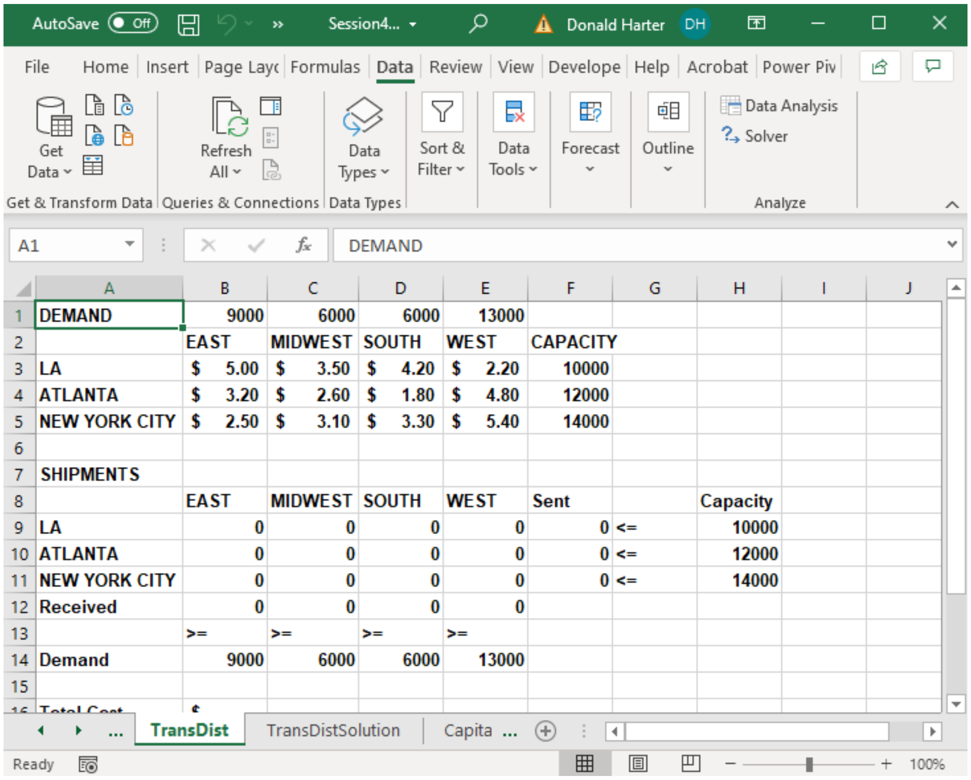
4.6 Transportation and distribution

The transportation and distribution problem describes an opportunity to minimize transportation costs. There are three distribution centers with inventory to be shipped to four destinations. The goal is to minimize transportation costs but satisfy all demand for the products at all locations. Use the TransDist spreadsheet. The initial spreadsheet looks like the picture below:



	A	B	C	D	E	F	G	H
1	DEMAND	9000	6000	6000	13000			
2		EAST	MIDWEST	SOUTH	WEST	CAPACITY		
3	LA	$ 5.00	$ 3.50	$ 4.20	$ 2.20	10000		
4	ATLANTA	$ 3.20	$ 2.60	$ 1.80	$ 4.80	12000		
5	NEW YORK CITY	$ 2.50	$ 3.10	$ 3.30	$ 5.40	14000		
6								
7	SHIPMENTS							
8		EAST	MIDWEST	SOUTH	WEST	Sent		Capacity
9	LA	0	0	0	0	0	<=	10000
10	ATLANTA	0	0	0	0	0	<=	12000
11	NEW YORK CITY	0	0	0	0	0	<=	14000
12	Received	0	0	0	0			
13		>=	>=	>=	>=			
14	Demand	9000	6000	6000	13000			
15								

The steps to minimize cost are:

1. Set the Objective to the total cost B16. See the formula in the cell. Why does this work?
2. Set the changing cells (B9:E11) to amount in inventory at each city which is shipped to each region (destination).
3. Set the constraints to reflect the capacity of the distribution center (Sent <= Capacity)
4. Set the constraints to reflect that you must satisfy demand for each region (Received => Demand)

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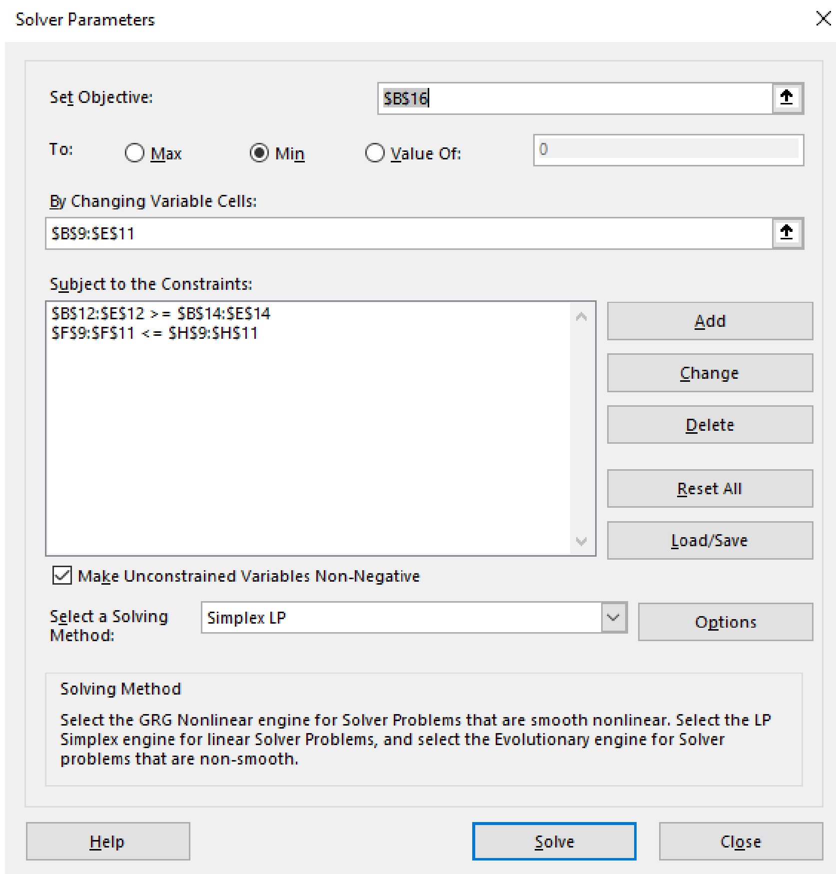
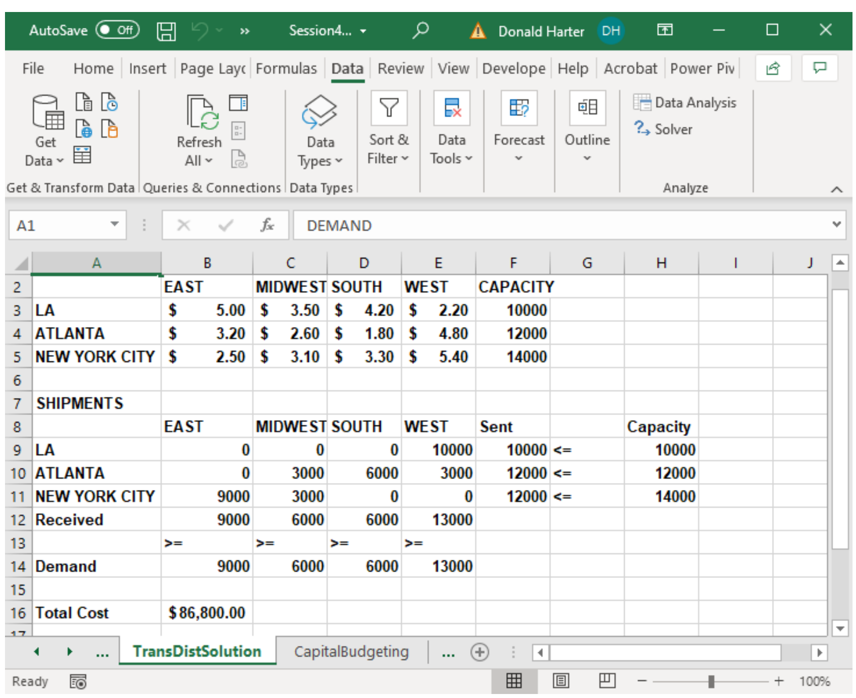


5. Click Solve, then OK



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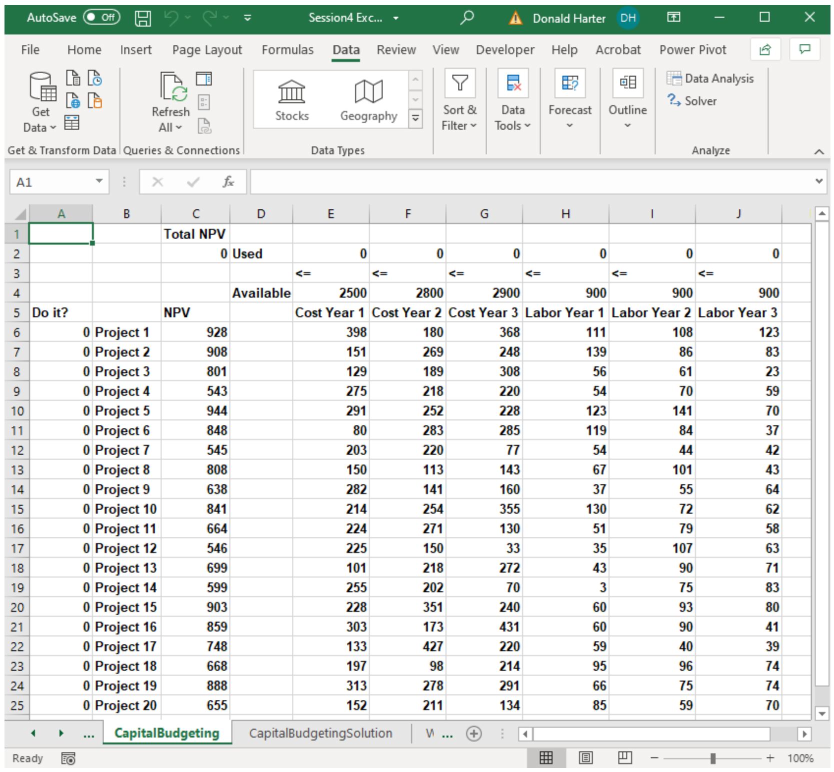
4.7 Capital budgeting

Using NPV (net present value) and IRR (internal rate of return), we are able to compare projects. Solver can be used for Capital Budgeting to select the optimal projects from a budgeting perspective.

In this case, we will use a trick called binary changing cells. A binary changing cell has a value of one or zero, reflecting that a project is selected or not. We will use a constraint of “bin” to designate a binary changing cell.



	A	B	C	D	E	F	G	H	I	J
1			Total NPV							
2			0	Used	0	0	0	0	0	0
3					<=	<=	<=	<=	<=	<=
4				Available	2500	2800	2900	900	900	900
5	Do it?		NPV		Cost Year 1	Cost Year 2	Cost Year 3	Labor Year 1	Labor Year 2	Labor Year 3
6	0	Project 1	928		398	180	368	111	108	123
7	0	Project 2	908		151	269	248	139	86	83
8	0	Project 3	801		129	189	308	56	61	23
9	0	Project 4	543		275	218	220	54	70	59
10	0	Project 5	944		291	252	228	123	141	70
11	0	Project 6	848		80	283	285	119	84	37
12	0	Project 7	545		203	220	77	54	44	42
13	0	Project 8	808		150	113	143	67	101	43
14	0	Project 9	638		282	141	160	37	55	64
15	0	Project 10	841		214	254	355	130	72	62
16	0	Project 11	664		224	271	130	51	79	58
17	0	Project 12	546		225	150	33	35	107	63
18	0	Project 13	699		101	218	272	43	90	71
19	0	Project 14	599		255	202	70	3	75	83
20	0	Project 15	903		228	351	240	60	93	80
21	0	Project 16	859		303	173	431	60	90	41
22	0	Project 17	748		133	427	220	59	40	39
23	0	Project 18	668		197	98	214	95	96	74
24	0	Project 19	888		313	278	291	66	75	74
25	0	Project 20	655		152	211	134	85	59	70

In the spreadsheet above, there are 20 projects, each with an NPV, yearly cost and yearly labor requirement. However, there also is a limit to available funds and personnel, listed in the Available row. Your objective is to select the projects within the funding and personnel constraints which maximize total NPV.

The following steps maximize NPV:

1. Set target cell to Total NPV value.
2. Set changing cells to the range of A6:A25 zeroes and ones.
3. Set constraints to reflect that funds and employees (E2:J2) used cannot exceed what is available (E4:J4).
4. Now click Solve to see the result.

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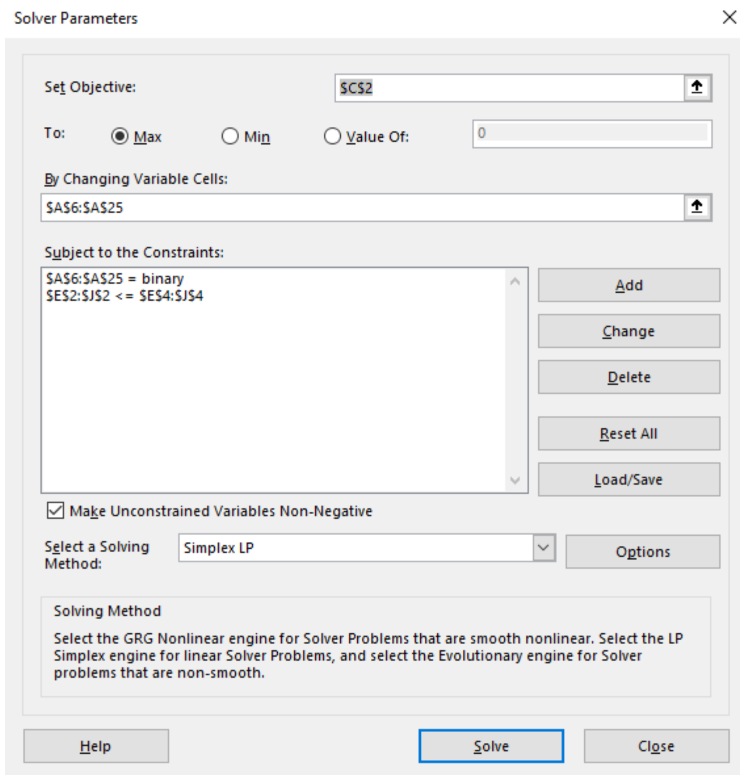

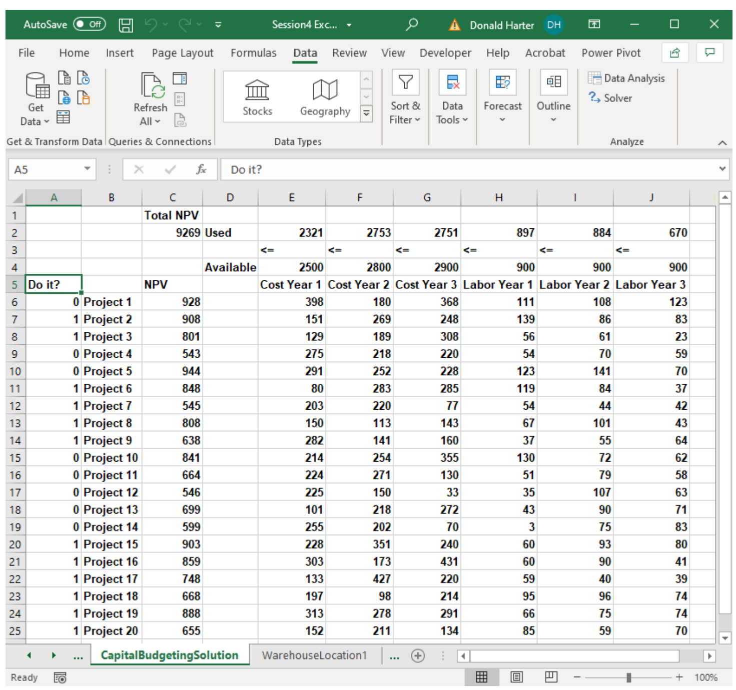

	A	B	C	D	E	F	G	H	I	J
1			Total NPV							
2			9269	Used	2321	2753	2751	897	884	670
3					<=	<=	<=	<=	<=	<=
4				Available	2500	2800	2900	900	900	900
5	Do it?		NPV		Cost Year 1	Cost Year 2	Cost Year 3	Labor Year 1	Labor Year 2	Labor Year 3
6	0	Project 1	928		398	180	368	111	108	123
7	1	Project 2	908		151	269	248	139	86	83
8	1	Project 3	801		129	189	308	56	61	23
9	0	Project 4	543		275	218	220	54	70	59
10	0	Project 5	944		291	252	228	123	141	70
11	1	Project 6	848		80	283	285	119	84	37
12	1	Project 7	545		203	220	77	54	44	42
13	1	Project 8	808		150	113	143	67	101	43
14	1	Project 9	638		282	141	160	37	55	64
15	0	Project 10	841		214	254	355	130	72	62
16	0	Project 11	664		224	271	130	51	79	58
17	0	Project 12	546		225	150	33	35	107	63
18	0	Project 13	699		101	218	272	43	90	71
19	0	Project 14	599		255	202	70	3	75	83
20	1	Project 15	903		228	351	240	60	93	80
21	1	Project 16	859		303	173	431	60	90	41
22	1	Project 17	748		133	427	220	59	40	39
23	1	Project 18	668		197	98	214	95	96	74
24	1	Project 19	888		313	278	291	66	75	74
25	1	Project 20	655		152	211	134	85	59	70

5. How would you handle other constraints, such as, if you select project 4, then project 3 must also be selected?
6. If you only have four project managers, how would you limit the selection to four projects?

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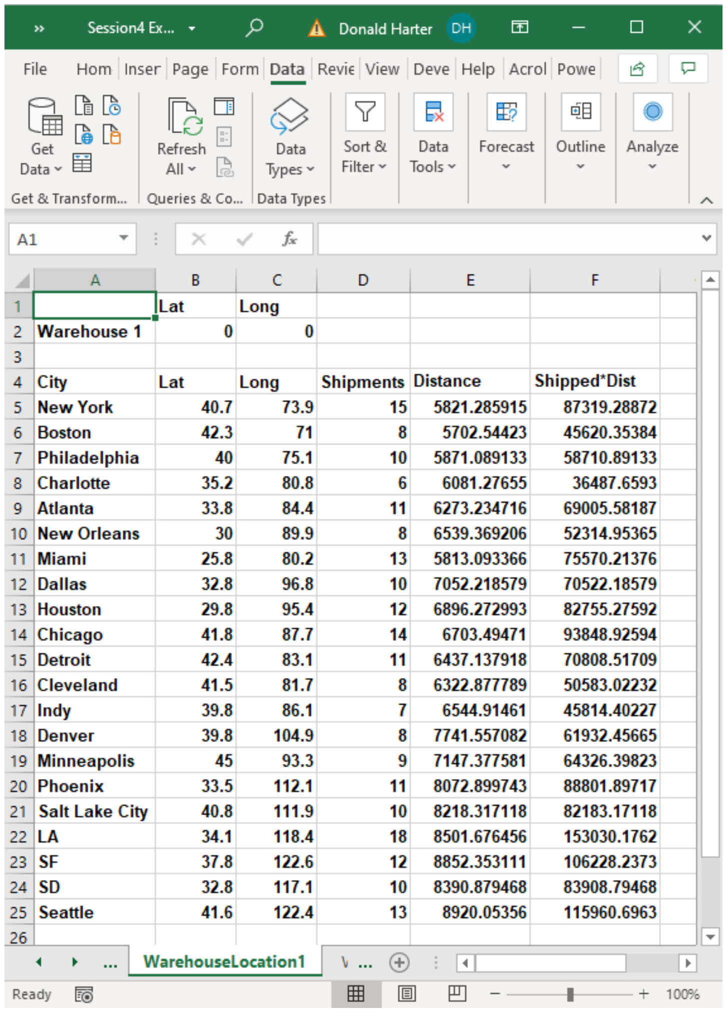
4.8 Warehouse Location – One Warehouse

You can use solver to find the optimal location for a warehouse, which minimizes the shipping distances for all shipments. We will try to find the optimal location for one warehouse to minimize shipment miles across the country, then expand to two warehouses.

1. For the first example in locating one warehouse, use the WarehouseLocation1 spreadsheet.



	A	B	C	D	E	F
1		Lat	Long			
2	Warehouse 1	0	0			
3						
4	City	Lat	Long	Shipments	Distance	Shipped*Dist
5	New York	40.7	73.9	15	5821.285915	87319.28872
6	Boston	42.3	71	8	5702.54423	45620.35384
7	Philadelphia	40	75.1	10	5871.089133	58710.89133
8	Charlotte	35.2	80.8	6	6081.27655	36487.6593
9	Atlanta	33.8	84.4	11	6273.234716	69005.58187
10	New Orleans	30	89.9	8	6539.369206	52314.95365
11	Miami	25.8	80.2	13	5813.093366	75570.21376
12	Dallas	32.8	96.8	10	7052.218579	70522.18579
13	Houston	29.8	95.4	12	6896.272993	82755.27592
14	Chicago	41.8	87.7	14	6703.49471	93848.92594
15	Detroit	42.4	83.1	11	6437.137918	70808.51709
16	Cleveland	41.5	81.7	8	6322.877789	50583.02232
17	Indy	39.8	86.1	7	6544.91461	45814.40227
18	Denver	39.8	104.9	8	7741.557082	61932.45665
19	Minneapolis	45	93.3	9	7147.377581	64326.39823
20	Phoenix	33.5	112.1	11	8072.899743	88801.89717
21	Salt Lake City	40.8	111.9	10	8218.317118	82183.17118
22	LA	34.1	118.4	18	8501.676456	153030.1762
23	SF	37.8	122.6	12	8852.353111	106228.2373
24	SD	32.8	117.1	10	8390.879468	83908.79468
25	Seattle	41.6	122.4	13	8920.05356	115960.6963
26						

2. Each city is identified with latitude and longitude, the number of shipments going to that city, calculated distance from the city to the warehouse, and shipping miles (Shipped*Dist) for each city
3. The goal is to minimize the Total Distance by finding the best location for warehouse 1.

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4. To calculate the distance from each city to the warehouse, we will use the Pythagorean theorem:

   $C^2 = A^2 + B^2$

5. Or, taking the square root of both sides:

   C = SQRT(A^2 + $B^{2)}$

6. For example, to calculate the distance from Dallas to Columbus:

7. We can approximate the distance A:

   A = latitude of Columbus – latitude of Dallas

8. We can approximate the distance B:

   B = longitude of Columbus – longitude of Dallas

9. Then the distance C is:

   C = SQRT((lat(Columbus)-lat(Dallas))^2 + (long(Columbus)-long(Dallas))^2)

10. One degree of latitude or longitude is approximately 69 miles, so the distance in miles is:

    Distance = 69*SQRT((lat(Columbus)-lat(Dallas))^2 + (long(Columbus)-long(Dallas))^2)

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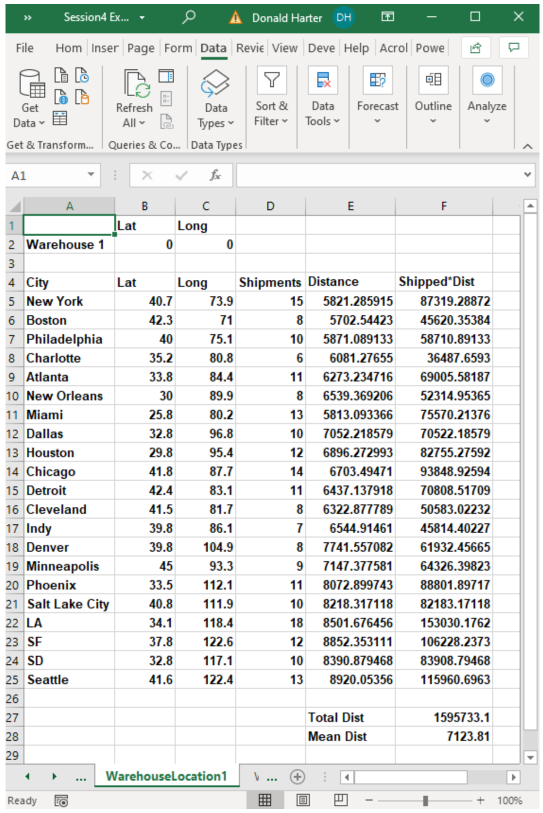
11. In column E, we calculate the distance from the warehouse to each city.
12. In column F, calculate the number of shipments * distance, so we have total miles driven.
13. In F27, create total distance for all cities



	A	B	C	D	E	F
1		Lat	Long			
2	Warehouse 1	0	0			
3						
4	City	Lat	Long	Shipments	Distance	Shipped*Dist
5	New York	40.7	73.9	15	5821.285915	87319.28872
6	Boston	42.3	71	8	5702.54423	45620.35384
7	Philadelphia	40	75.1	10	5871.089133	58710.89133
8	Charlotte	35.2	80.8	6	6081.27655	36487.6593
9	Atlanta	33.8	84.4	11	6273.234716	69005.58187
10	New Orleans	30	89.9	8	6539.369206	52314.95365
11	Miami	25.8	80.2	13	5813.093366	75570.21376
12	Dallas	32.8	96.8	10	7052.218579	70522.18579
13	Houston	29.8	95.4	12	6896.272993	82755.27592
14	Chicago	41.8	87.7	14	6703.49471	93848.92594
15	Detroit	42.4	83.1	11	6437.137918	70808.51709
16	Cleveland	41.5	81.7	8	6322.877789	50583.02232
17	Indy	39.8	86.1	7	6544.91461	45814.40227
18	Denver	39.8	104.9	8	7741.557082	61932.45665
19	Minneapolis	45	93.3	9	7147.377581	64326.39823
20	Phoenix	33.5	112.1	11	8072.899743	88801.89717
21	Salt Lake City	40.8	111.9	10	8218.317118	82183.17118
22	LA	34.1	118.4	18	8501.676456	153030.1762
23	SF	37.8	122.6	12	8852.353111	106228.2373
24	SD	32.8	117.1	10	8390.879468	83908.79468
25	Seattle	41.6	122.4	13	8920.05356	115960.6963
26						
27					Total Dist	1595733.1
28					Mean Dist	7123.81
29						

14. To run solver, click on the Data tab, then Solver
15. The objective is to minimize total distance, so enter F27 in Set Objective
16. We want to change the warehouse location, so set By Change Variable Cells to B2:C2, the latitude and longitude for the warehouse
17. Select a solving method of GRG nonlinear.
18. Click Solve

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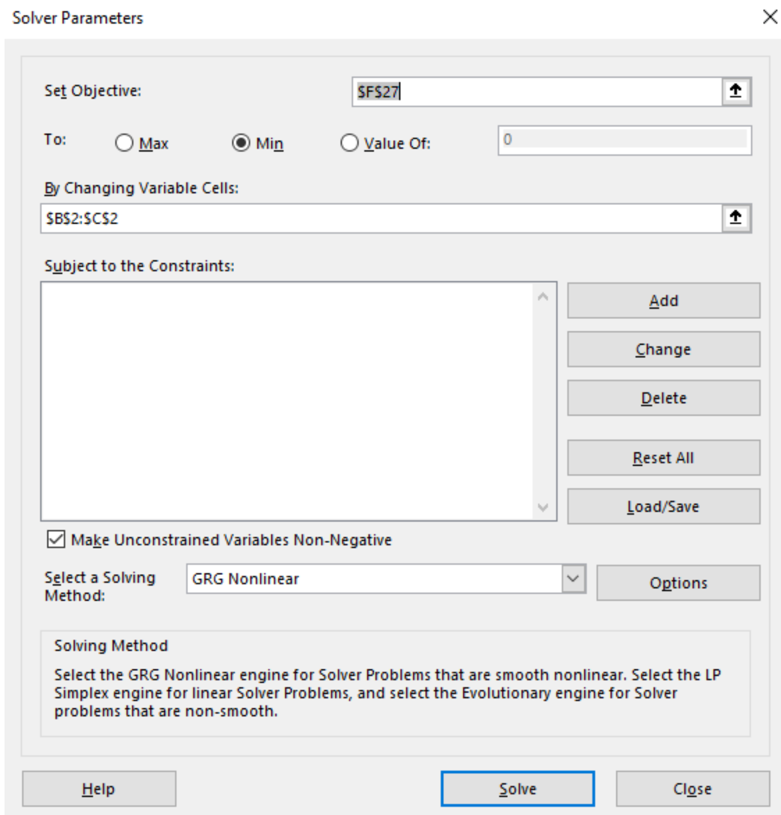
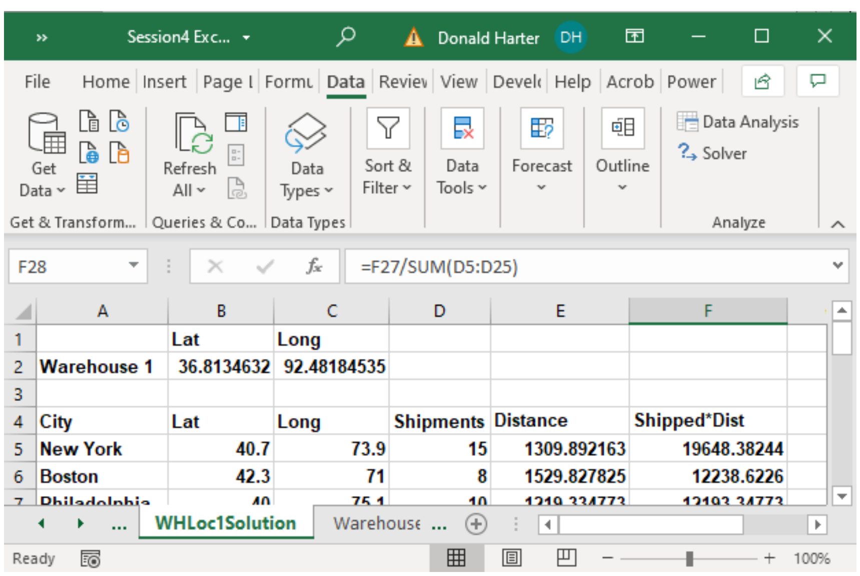


19. The solution is 36.81 N, 92.48 W. Use Google Maps to identify the location



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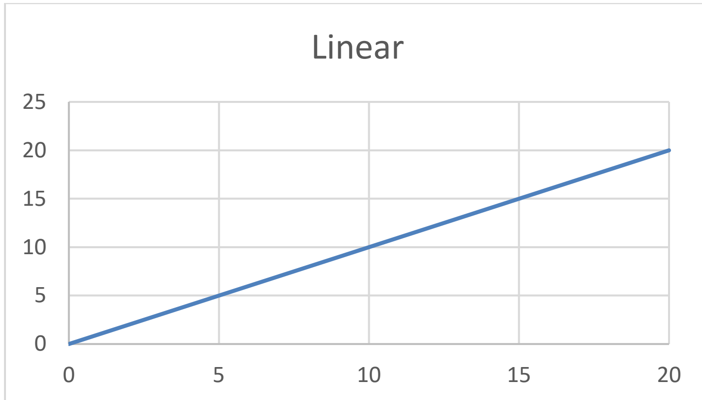
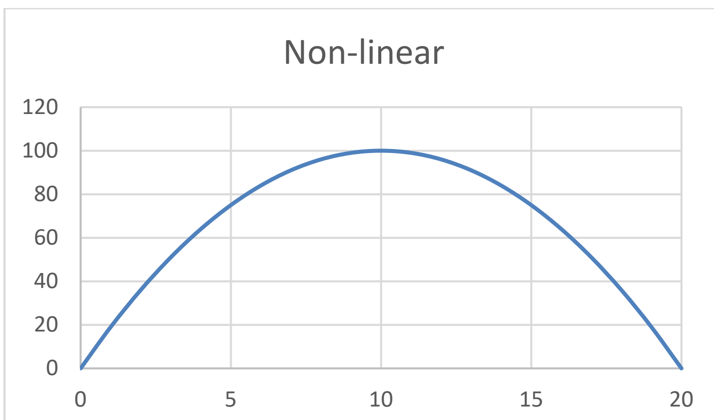
4.9 Solving Non-linear Problems in Solver

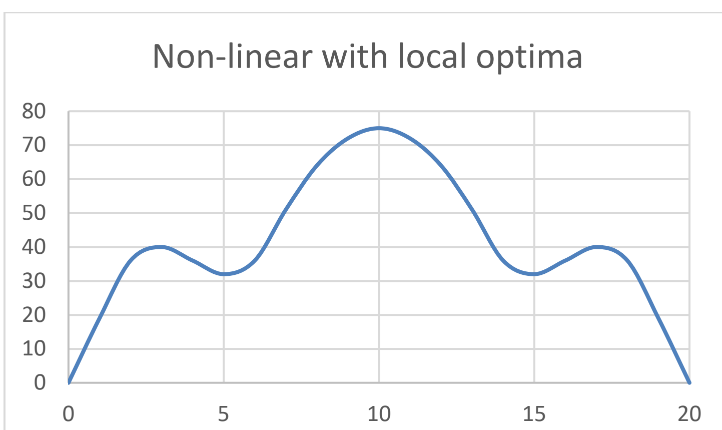
The simplest Objective curves will be linear. The Simplex method is sufficient when the function is linear.



Non-linear equations require a non-linear solution. GRG Nonlinear can solve this.



Non-linear with local optima require multiple starting points. GRG Nonlinear with multi-start works here.



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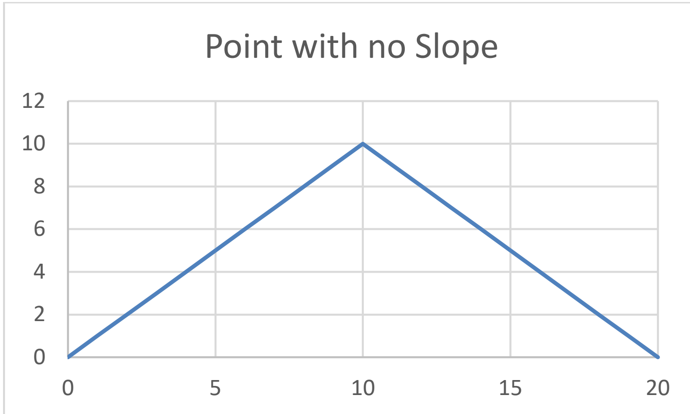
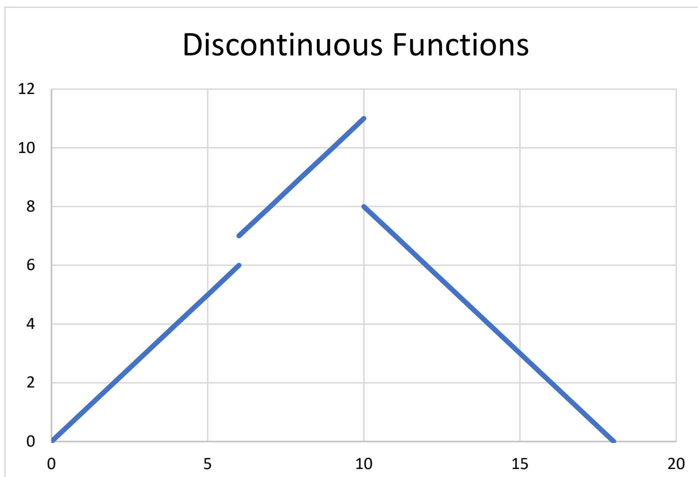
Equations with point having no slope or discontinuous functions must use evolutionary.





Summary of technique selection

The following table summarizes which techniques can solve each type of problem.

	Solution Technique			
Problem	Simplex	GRG Non-linear	GRG Non-linear with multi-start	Evolutionary
Linear	Yes	Yes	Yes	Yes
Nonlinear, one optimum	No	Yes	Yes	Yes
Nonlinear, multiple optima	No	No	Yes	Yes
Curve has point with no slope	No	No	No	Yes
Speed	Fastest	Fast	Slow	Slowest

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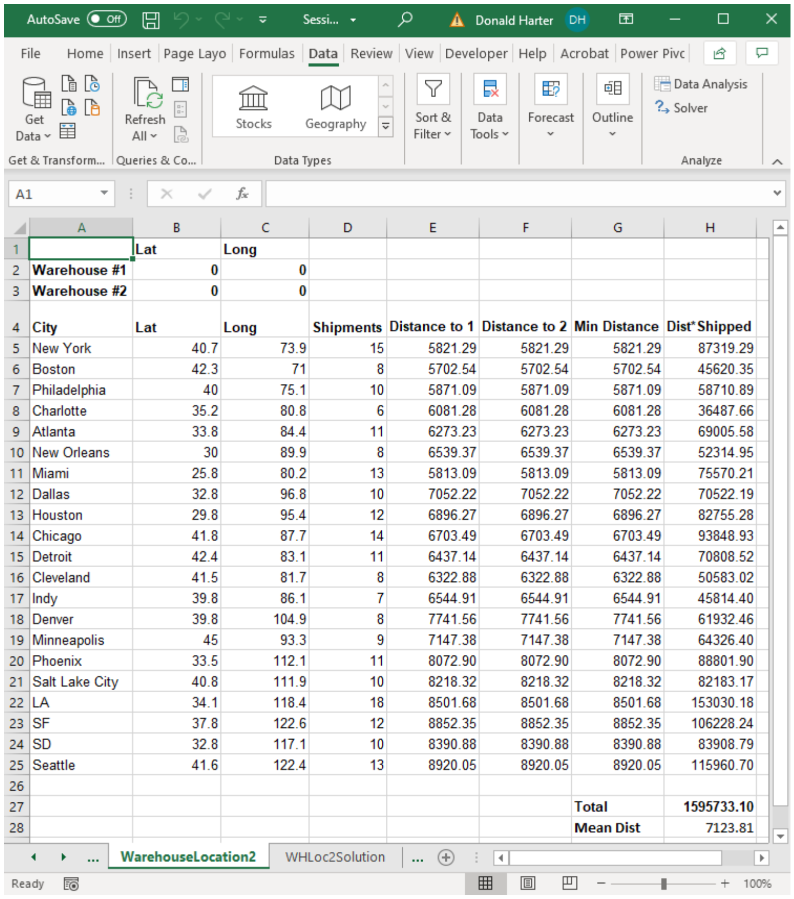
4.10 Warehouse Location – Two Warehouses

Now, assume that we will locate two warehouses.



	A	B	C	D	E	F	G	H
1		Lat	Long					
2	Warehouse #1	0	0					
3	Warehouse #2	0	0					
4	City	Lat	Long	Shipments	Distance to 1	Distance to 2	Min Distance	Dist*Shipped
5	New York	40.7	73.9	15	5821.29	5821.29	5821.29	87319.29
6	Boston	42.3	71	8	5702.54	5702.54	5702.54	45620.35
7	Philadelphia	40	75.1	10	5871.09	5871.09	5871.09	58710.89
8	Charlotte	35.2	80.8	6	6081.28	6081.28	6081.28	36487.66
9	Atlanta	33.8	84.4	11	6273.23	6273.23	6273.23	69005.58
10	New Orleans	30	89.9	8	6539.37	6539.37	6539.37	52314.95
11	Miami	25.8	80.2	13	5813.09	5813.09	5813.09	75570.21
12	Dallas	32.8	96.8	10	7052.22	7052.22	7052.22	70522.19
13	Houston	29.8	95.4	12	6896.27	6896.27	6896.27	82755.28
14	Chicago	41.8	87.7	14	6703.49	6703.49	6703.49	93848.93
15	Detroit	42.4	83.1	11	6437.14	6437.14	6437.14	70808.52
16	Cleveland	41.5	81.7	8	6322.88	6322.88	6322.88	50583.02
17	Indy	39.8	86.1	7	6544.91	6544.91	6544.91	45814.40
18	Denver	39.8	104.9	8	7741.56	7741.56	7741.56	61932.46
19	Minneapolis	45	93.3	9	7147.38	7147.38	7147.38	64326.40
20	Phoenix	33.5	112.1	11	8072.90	8072.90	8072.90	88801.90
21	Salt Lake City	40.8	111.9	10	8218.32	8218.32	8218.32	82183.17
22	LA	34.1	118.4	18	8501.68	8501.68	8501.68	153030.18
23	SF	37.8	122.6	12	8852.35	8852.35	8852.35	106228.24
24	SD	32.8	117.1	10	8390.88	8390.88	8390.88	83908.79
25	Seattle	41.6	122.4	13	8920.05	8920.05	8920.05	115960.70
26								
27							Total	1595733.10
28							Mean Dist	7123.81

1. The latitude and longitude for our two warehouses are at the top of the screen.
2. The only additions that we have are two distance calculations (city to warehouse 1 and city to warehouse 2) and the minimum distance of the two. Our goal is to minimize total distance. In this case, we will assume that each city will receive shipments from the warehouse that is closest
3. To run solver, click on the Data tab, then Solver
4. The objective is to minimize total distance, so enter F27 in Set Objective
5. We want to change the warehouse location, so set By Change Variable Cells to B2:C3, the latitude and longitude for the warehouses
6. Select a solving method of GRG nonlinear.
7. Click Solve
8. Does the result make sense? The two warehouses are located in the same latitude and longitude.
9. Solver is stuck in a local solution

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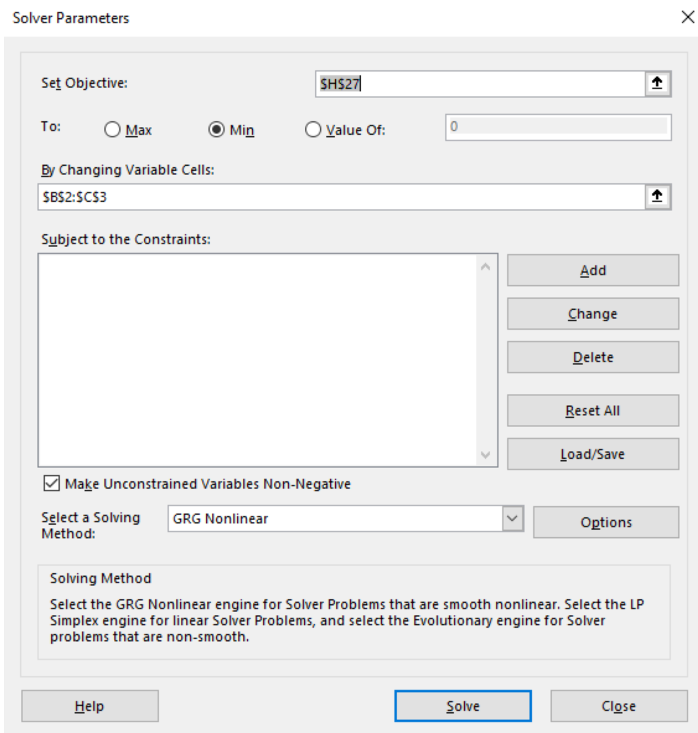

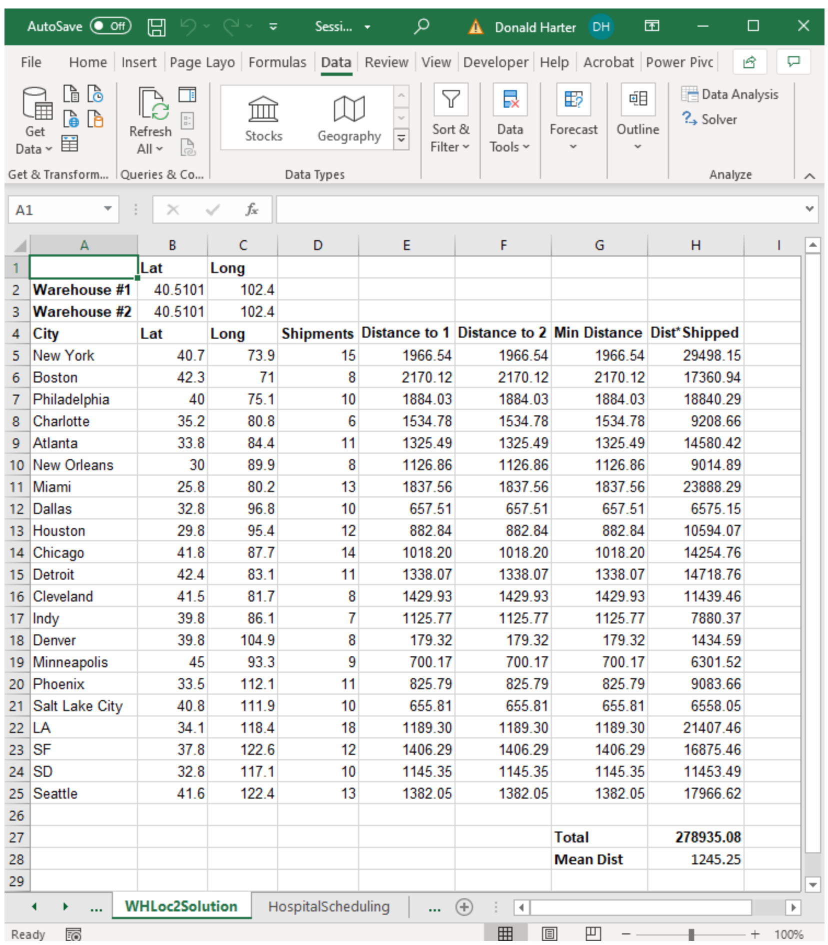

	A	B	C	D	E	F	G	H
1		Lat	Long					
2	Warehouse #1	40.5101	102.4					
3	Warehouse #2	40.5101	102.4					
4	City	Lat	Long	Shipments	Distance to 1	Distance to 2	Min Distance	Dist*Shipped
5	New York	40.7	73.9	15	1966.54	1966.54	1966.54	29498.15
6	Boston	42.3	71	8	2170.12	2170.12	2170.12	17360.94
7	Philadelphia	40	75.1	10	1884.03	1884.03	1884.03	18840.29
8	Charlotte	35.2	80.8	6	1534.78	1534.78	1534.78	9208.66
9	Atlanta	33.8	84.4	11	1325.49	1325.49	1325.49	14580.42
10	New Orleans	30	89.9	8	1126.86	1126.86	1126.86	9014.89
11	Miami	25.8	80.2	13	1837.56	1837.56	1837.56	23888.29
12	Dallas	32.8	96.8	10	657.51	657.51	657.51	6575.15
13	Houston	29.8	95.4	12	882.84	882.84	882.84	10594.07
14	Chicago	41.8	87.7	14	1018.20	1018.20	1018.20	14254.76
15	Detroit	42.4	83.1	11	1338.07	1338.07	1338.07	14718.76
16	Cleveland	41.5	81.7	8	1429.93	1429.93	1429.93	11439.46
17	Indy	39.8	86.1	7	1125.77	1125.77	1125.77	7880.37
18	Denver	39.8	104.9	8	179.32	179.32	179.32	1434.59
19	Minneapolis	45	93.3	9	700.17	700.17	700.17	6301.52
20	Phoenix	33.5	112.1	11	825.79	825.79	825.79	9083.66
21	Salt Lake City	40.8	111.9	10	655.81	655.81	655.81	6558.05
22	LA	34.1	118.4	18	1189.30	1189.30	1189.30	21407.46
23	SF	37.8	122.6	12	1406.29	1406.29	1406.29	16875.46
24	SD	32.8	117.1	10	1145.35	1145.35	1145.35	11453.49
25	Seattle	41.6	122.4	13	1382.05	1382.05	1382.05	17966.62
26								
27							Total	278935.08
28							Mean Dist	1245.25
29								

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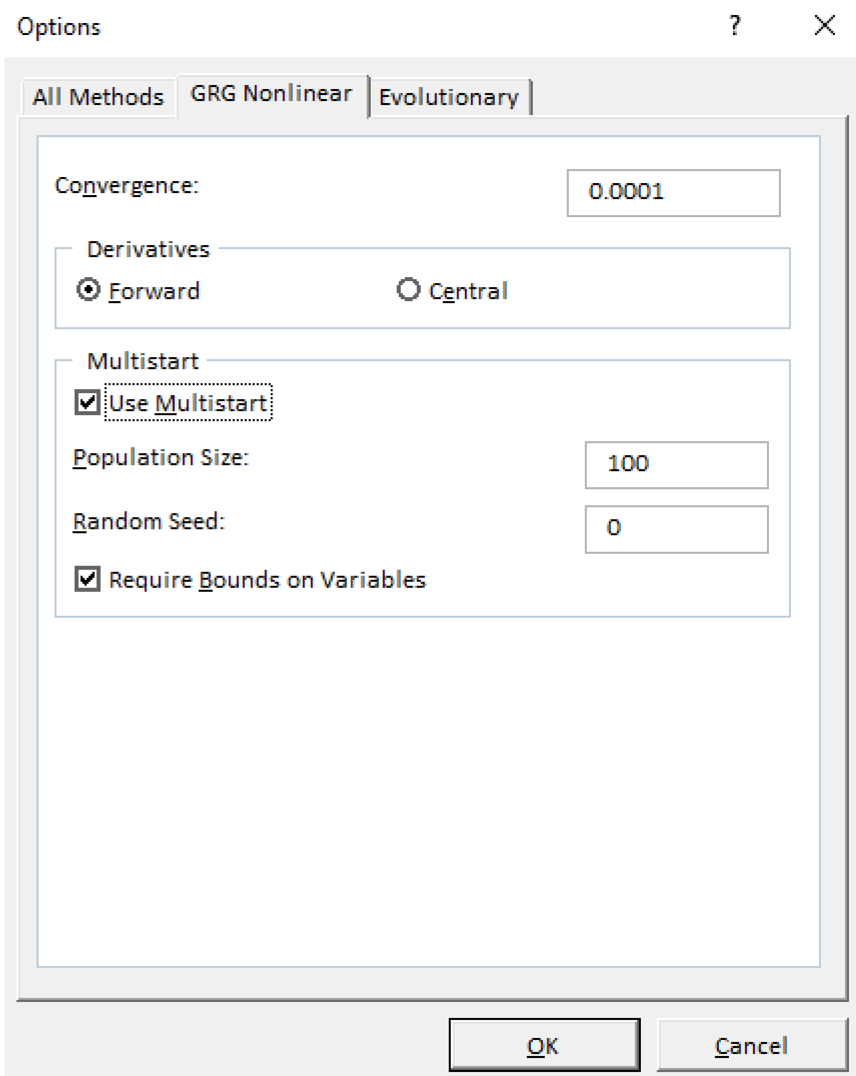
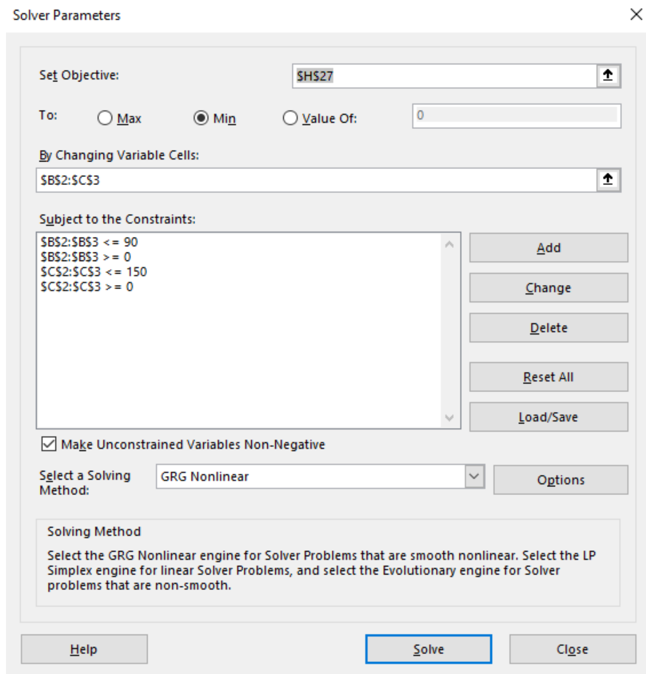
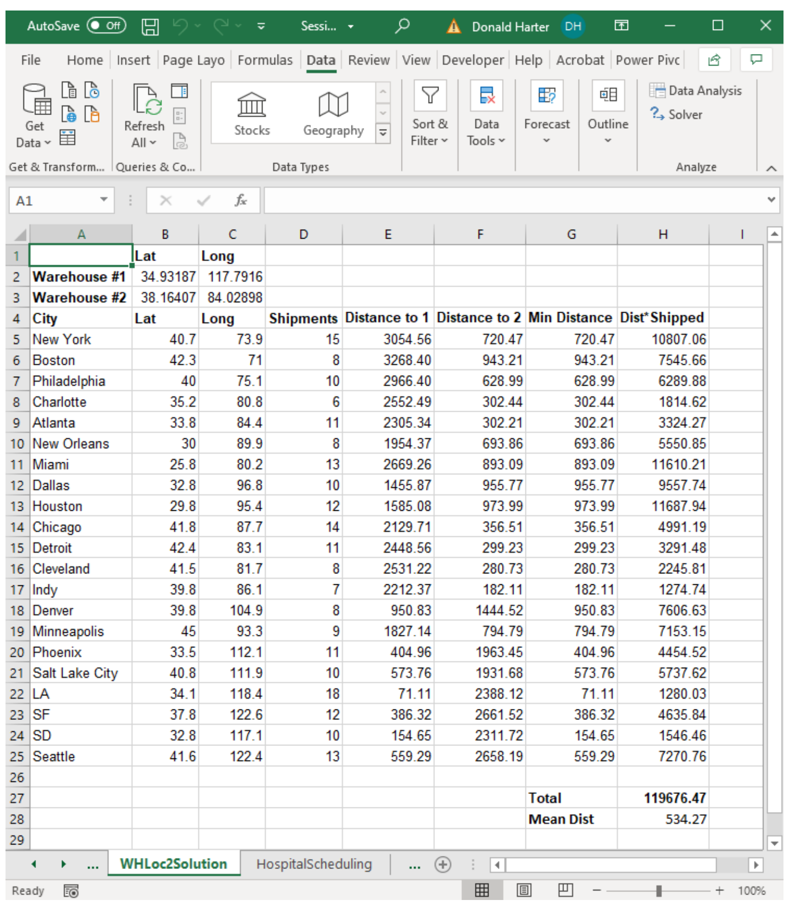
10. Now, let's use GRG Nonlinear with multiple start points
11. Click on solver
12. Next to GRG Nonlinear, click on Options
13. Click on the tab GRG Nonlinear
14. Check the box Use Multistart, then click OK
15. Note that it requires bounds on variables



16. Next add constraints that put bounds on the variables
17. In the Solver Parameters screen, under constraints, click Add
18. Add a constraint for B2:B3 >= 0
19. Add a constraint for B2:B3 <= 90
20. Add a constraint for C2:C3 >= 0
21. Add a constraint for C2:C3 <= 150
22. Click Solve
23. Use Google Maps to find the locations of the two warehouses





	A	B	C	D	E	F	G	H
1		Lat	Long					
2	Warehouse #1	34.93187	117.7916					
3	Warehouse #2	38.16407	84.02898					
4	City	Lat	Long	Shipments	Distance to 1	Distance to 2	Min Distance	Dist*Shipped
5	New York	40.7	73.9	15	3054.56	720.47	720.47	10807.06
6	Boston	42.3	71	8	3268.40	943.21	943.21	7545.66
7	Philadelphia	40	75.1	10	2966.40	628.99	628.99	6289.88
8	Charlotte	35.2	80.8	6	2552.49	302.44	302.44	1814.62
9	Atlanta	33.8	84.4	11	2305.34	302.21	302.21	3324.27
10	New Orleans	30	89.9	8	1954.37	693.86	693.86	5550.85
11	Miami	25.8	80.2	13	2669.26	893.09	893.09	11610.21
12	Dallas	32.8	96.8	10	1455.87	955.77	955.77	9557.74
13	Houston	29.8	95.4	12	1585.08	973.99	973.99	11687.94
14	Chicago	41.8	87.7	14	2129.71	356.51	356.51	4991.19
15	Detroit	42.4	83.1	11	2448.56	299.23	299.23	3291.48
16	Cleveland	41.5	81.7	8	2531.22	280.73	280.73	2245.81
17	Indy	39.8	86.1	7	2212.37	182.11	182.11	1274.74
18	Denver	39.8	104.9	8	950.83	1444.52	950.83	7606.63
19	Minneapolis	45	93.3	9	1827.14	794.79	794.79	7153.15
20	Phoenix	33.5	112.1	11	404.96	1963.45	404.96	4454.52
21	Salt Lake City	40.8	111.9	10	573.76	1931.68	573.76	5737.62
22	LA	34.1	118.4	18	71.11	2388.12	71.11	1280.03
23	SF	37.8	122.6	12	386.32	2661.52	386.32	4635.84
24	SD	32.8	117.1	10	154.65	2311.72	154.65	1546.46
25	Seattle	41.6	122.4	13	559.29	2658.19	559.29	7270.76
26								
27							Total	119676.47
28							Mean Dist	534.27
29								

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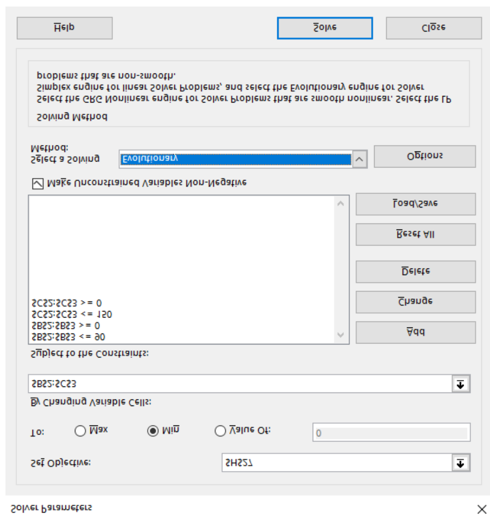
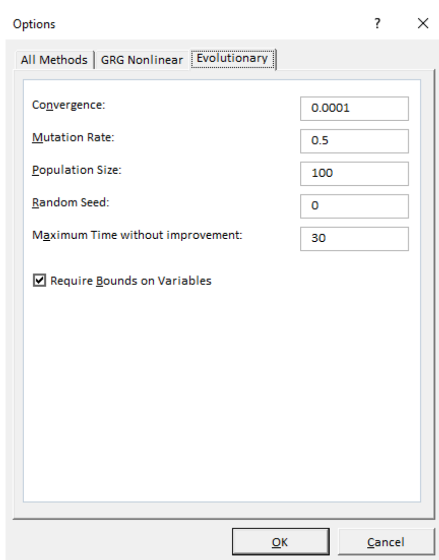
4.11 Evolutionary Solver

Run the same problem with Evolutionary

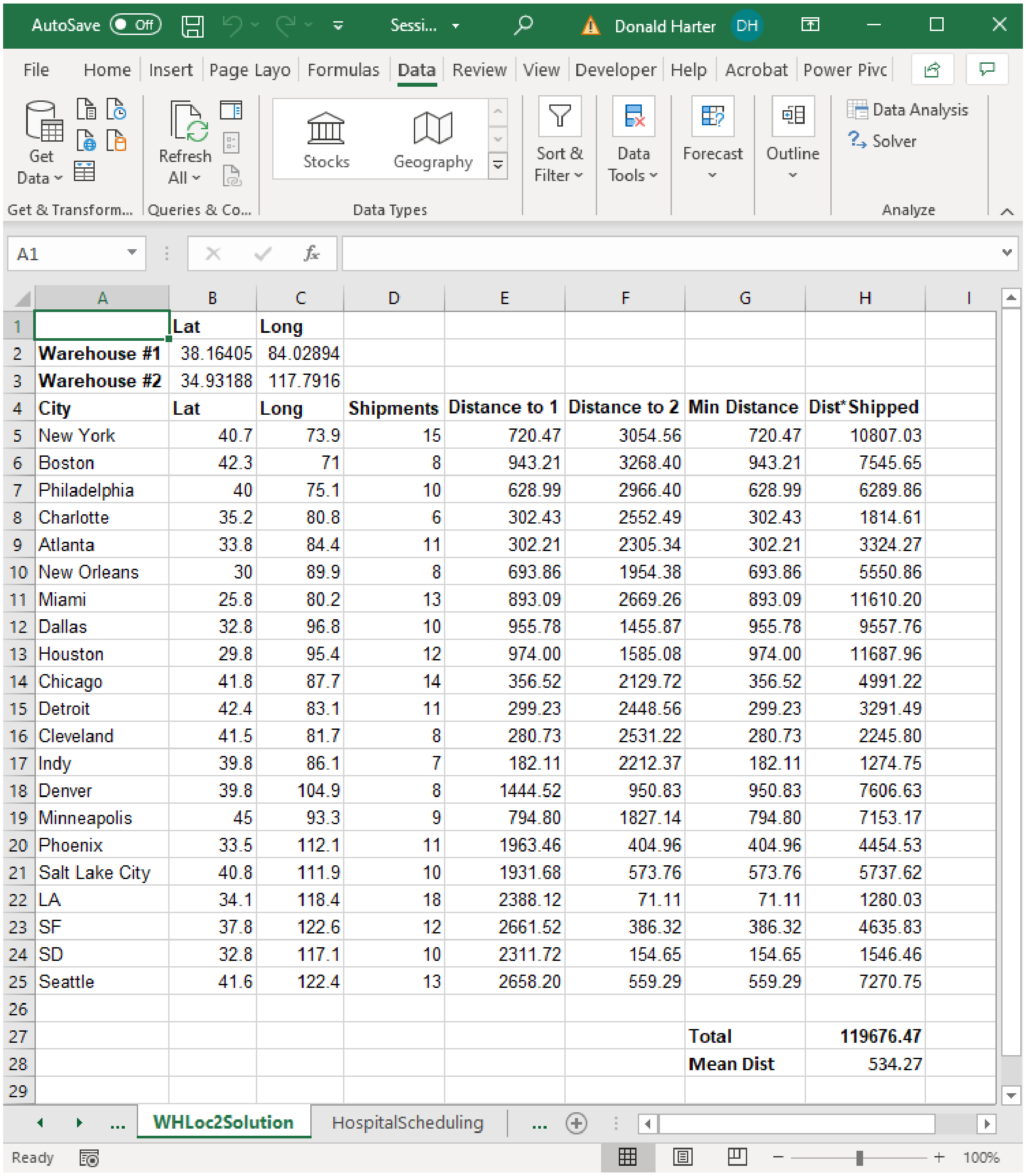
1. Set the objective to Total Distance (H27)
2. Set to Min so we minimize Total Distance
3. Set By Changing Variable Cells to B2:C3
4. Add a constraint for B2:B3 >= 0
5. Add a constraint for B2:B3 <= 90
6. Add a constraint for C2:C3 >= 0
7. Add a constraint for C2:C3 <= 150



8. Change Select a Solving Method to Evolutionary
9. Click on Options next to Evolutionary
10. Change Mutation Rate to 0.5
11. Check the box Require Bounds on Variables
12. Click OK



13. Solver will return the Evolutionary solution

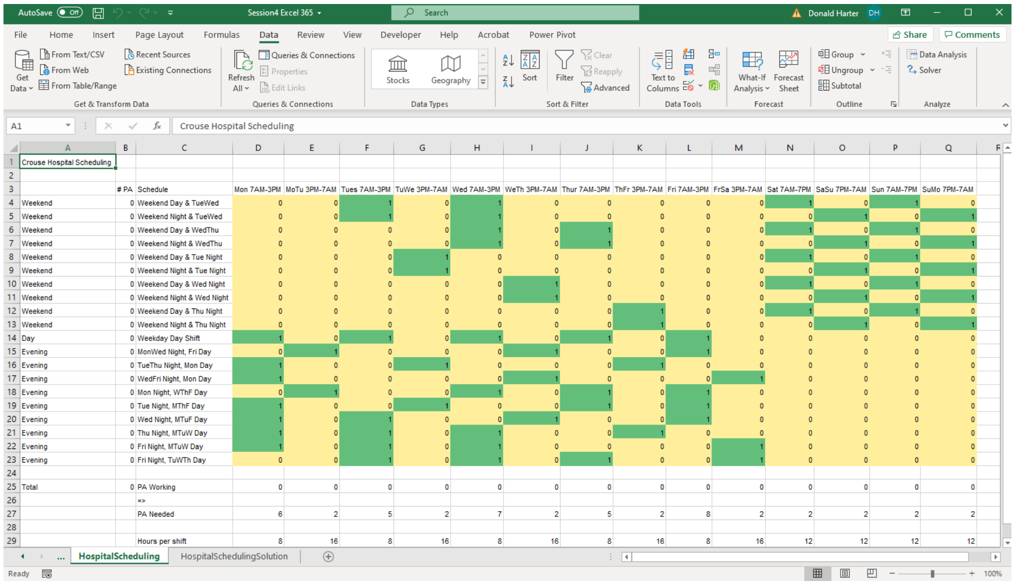


	A	B	C	D	E	F	G	H
1		**Lat**	**Long**					
2	**Warehouse #1**	38.16405	84.02894					
3	**Warehouse #2**	34.93188	117.7916					
4	**City**	**Lat**	**Long**	**Shipments**	**Distance to 1**	**Distance to 2**	**Min Distance**	**Dist*Shipped**
5	New York	40.7	73.9	15	720.47	3054.56	720.47	10807.03
6	Boston	42.3	71	8	943.21	3268.40	943.21	7545.65
7	Philadelphia	40	75.1	10	628.99	2966.40	628.99	6289.86
8	Charlotte	35.2	80.8	6	302.43	2552.49	302.43	1814.61
9	Atlanta	33.8	84.4	11	302.21	2305.34	302.21	3324.27
10	New Orleans	30	89.9	8	693.86	1954.38	693.86	5550.86
11	Miami	25.8	80.2	13	893.09	2669.26	893.09	11610.20
12	Dallas	32.8	96.8	10	955.78	1455.87	955.78	9557.76
13	Houston	29.8	95.4	12	974.00	1585.08	974.00	11687.96
14	Chicago	41.8	87.7	14	356.52	2129.72	356.52	4991.22
15	Detroit	42.4	83.1	11	299.23	2448.56	299.23	3291.49
16	Cleveland	41.5	81.7	8	280.73	2531.22	280.73	2245.80
17	Indy	39.8	86.1	7	182.11	2212.37	182.11	1274.75
18	Denver	39.8	104.9	8	1444.52	950.83	950.83	7606.63
19	Minneapolis	45	93.3	9	794.80	1827.14	794.80	7153.17
20	Phoenix	33.5	112.1	11	1963.46	404.96	404.96	4454.53
21	Salt Lake City	40.8	111.9	10	1931.68	573.76	573.76	5737.62
22	LA	34.1	118.4	18	2388.12	71.11	71.11	1280.03
23	SF	37.8	122.6	12	2661.52	386.32	386.32	4635.83
24	SD	32.8	117.1	10	2311.72	154.65	154.65	1546.46
25	Seattle	41.6	122.4	13	2658.20	559.29	559.29	7270.75
26								
27							**Total**	**119676.47**
28							**Mean Dist**	534.27
29								

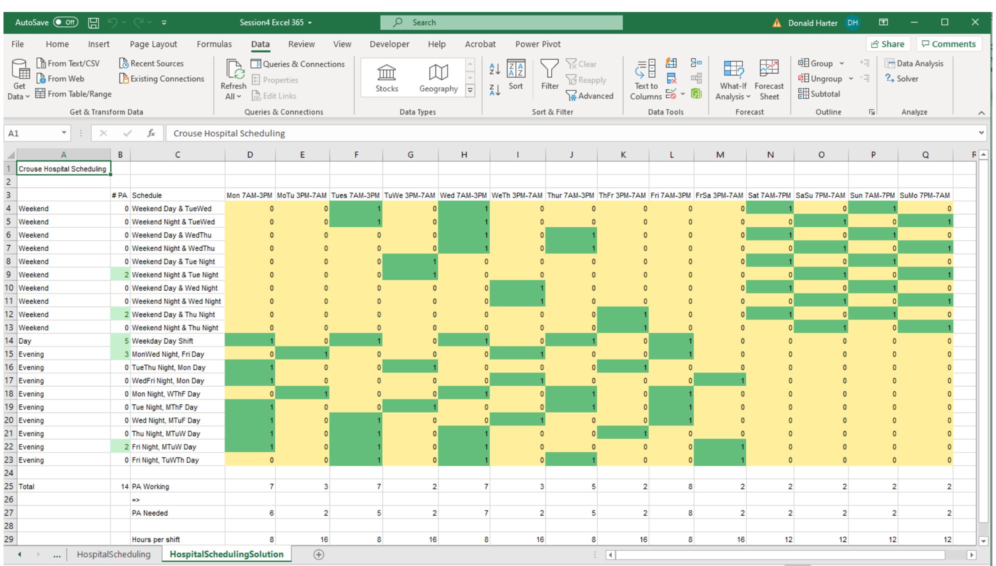
4.12 Crouse Hospital Scheduling

The following example is a real problem from Crouse Hospital. The chief of surgery is trying to determine how to assign physicians attending (PA) the emergency room. He currently has 13 physicians.

1. The spreadsheet represents the different possible shifts in the emergency room (ER)



2. Historical data indicates the minimum number of physicians that must be on staff for each shift (row 27: PA Needed)
3. The # PA (B column) represents how many physicians should be assigned to each shift.
4. The PA working (row 25) counts how many physicians have been assigned to each time slot.
5. The total (cell B25) is the total number of physicians required.
6. Minimize the total number of physicians assigned subject to the constraint that each time slot has enough PA Working to cover the PA Needed (PA Working => PA Needed)
7. Don't forget the constraint that you need whole physicians, not fractional physicians.



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