Solving a Refinery Problem with Excel Solver

	Type of Crude or Process					**Product Demand**
	A	**B**	**C_1**	**C_2**	**D**	
Profits on Crudes	10	20	15	25	7	
Products	**Product Slate for Crude or Process**					
G	0.6	0.5	0.4	0.4	0.3	**170**
H	0.2	0.2	0.3	0.1	0.3	**85**
F	0.1	0.2	0.2	0.2	0.3	**85**
L	0.0	0.0	0.0	0.2	0.0	**20**
Total Crude	**100**	**100**	**C_1+C_2 = 200**		**100**	

The objective function to maximize for this problem comes from multiplying each product by its profits and summing up or

$$\pi = 10*A + 20*B + 15*C_1 + 25*C_2 + 7*D.$$

The total gasoline from crude A is 0.6*A, from B it is 0.5*B, etc. To make sure we satisfy the gasoline market then our gasoline constraint must be

$$170 \leq 0.6*A + 0.5*B + 0.4*C_1 + 0.4*C_2 + 0.3*D.$$

Similarly our constraints for heating oil, fuel oil and lubes are

$$85 \leq 0.2*A + 0.2*B + 0.3*C_1 + 0.1*C_2 + 0.3*D,$$

$$85 \leq 0.1*A + 0.2*B + 0.2*C_1 + 0.2*C_2 + 0.3*D, \text{ and}$$

$$20 \leq 0.2*C_2.$$

In addition, we can not use more crude oil than we have at our disposal, so the crude oil constraints are

$$A \leq 100,$$

$$B \leq 100,$$

$$C_1 + C_2 \leq 200,$$

$$D \leq 100.$$

With this more complicated problem, we will solve using a computer. We will use Solver in Excel for MS Office 2000, which is quite user friendly and widely available. (Directions for other versions may vary slightly.) To start, go to a new worksheet in Excel and enter the following profit values in **C1** to **G1** as follows: (Note the bold faced values are addresses and should not be typed in the cell)

C1: 10

D1: 20

E1: 15

F1: 25

G1: 7

Put a profit label in cell **A2**

A2: Profit =

Create the formula for the profit function in **B2** as follows. Be sure to type the = sign so Excel will know you are typing a formula. Then

B2: = C2*C1 + D2*D1 + E2*E1 + F2*F1 + G2*G1

The solution values to maximize the formula in **B2** will be in **C2** to **G2**. Start out with some sample values. A good starting point might be to put 100 in each cell, which assumes that all crudes are run at capacity or

C2: 100

D2: 100

E2: 100

F2: 100

G2: 100

Put a label in **A3**. Product constraints =

Then type the labels and constraints for crude and products as

B4: G

C4: 170

D4: = 0.6*C2+ 0.5*D2 + 0.4*E2 + 0.4*F2 + 0.3*G2

B5: H

C5: 85

D5: = 0.2*C2+0.2*D2 + 0.3*E2 + 0.1*F2 + 0.3*G2

B6: F

C6: 85

D6: = 0.1*C2 + 0.2*D2 + 0.2*E2 + 0.2*F2 + 0.3*G2

B7: L

C7: 20

D7: = 0.2*F2

A8: The crude oil constraints are

B9: A

C9: = C2

D9: 100

B10: B

C10: = D2

D10: 100

B11: C

C11: = E2 + F2

D11: 200

B12: D

C12: = G2

D12: 100

Last we need to ensure that the model does not come up with negative crude values, so we will need 5 more constraints. If you solved the above model without the non-negativity constraints you will find that Excel will make one of the crude runs negative. Enter the negativity constraints as follows:

A13: Nonzero Constraints

B14: 0<=A

B15: 0<=B

B16: 0<=C1

B17: 0<=C2

B18: 0<=D

C14: 0

C15: 0

C16: 0

C17: 0

C18: 0

D14: =C2

D15: = D2

D16: = E2

D17: = F2

D18: = G2

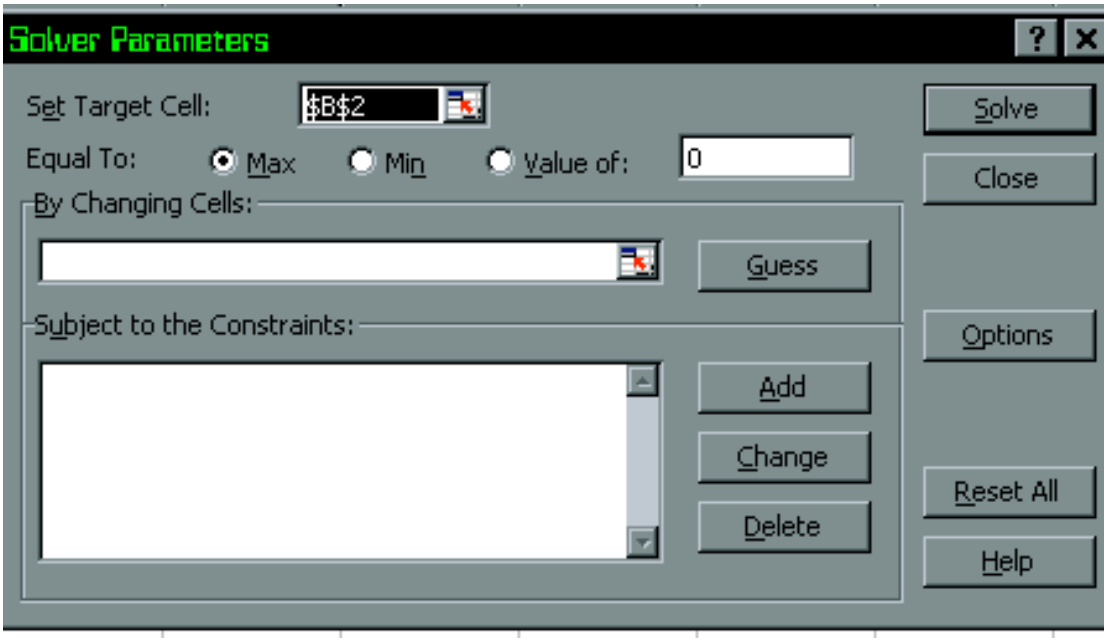
Alternatively if all your choice variables have to be positive you can go to **>Options** and check **Assume Nonnegative.** Also click **Assume Linear Model** to speed up the solution to the problem. Note all the constraints are set up to be less than or equal to constraints. Solver tends to work better if all the inequality constraints are arranged in the same direction. When you are finished your work sheet should look as follows. The bold faced letters and numbers along the edge of the spread sheets are address labels. The shaded cells can be changed if your profits or constraints change but the refining technology stays the same.

Table 14.7 Worksheet for Refinery Optimization Problem

	A	B	C	D	E	F	G
1			10	20	15	25	7
2	Profit =	8,700	100	100	0	200	100
3	Product constraints are						
4		G	170	220			
5		H	85	90			
6		F	85	100			
7		L	20	40			
8	Crude oil contraints are						
9		A	100	100			
10		B	100	100			
11		C	200	200			
12		D	100	100			
13	Non-zero Constraints						
14		0<=A	0	100			
15		0<=B	0	100			
16		0<=C1	0	0			
17		0<=C2	0	200			
18		0<=D	0	100			

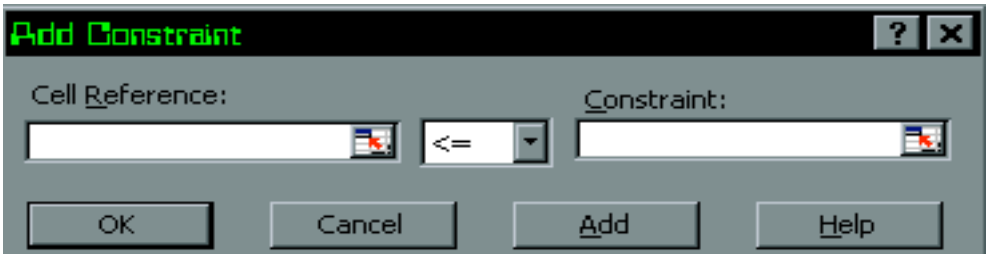
To solve this model move to cell B2 and then go to **Tools**, **Solver**. The following menu in **Figure 14.5** should come up.

Figure 14.5 Excel Solver Menu



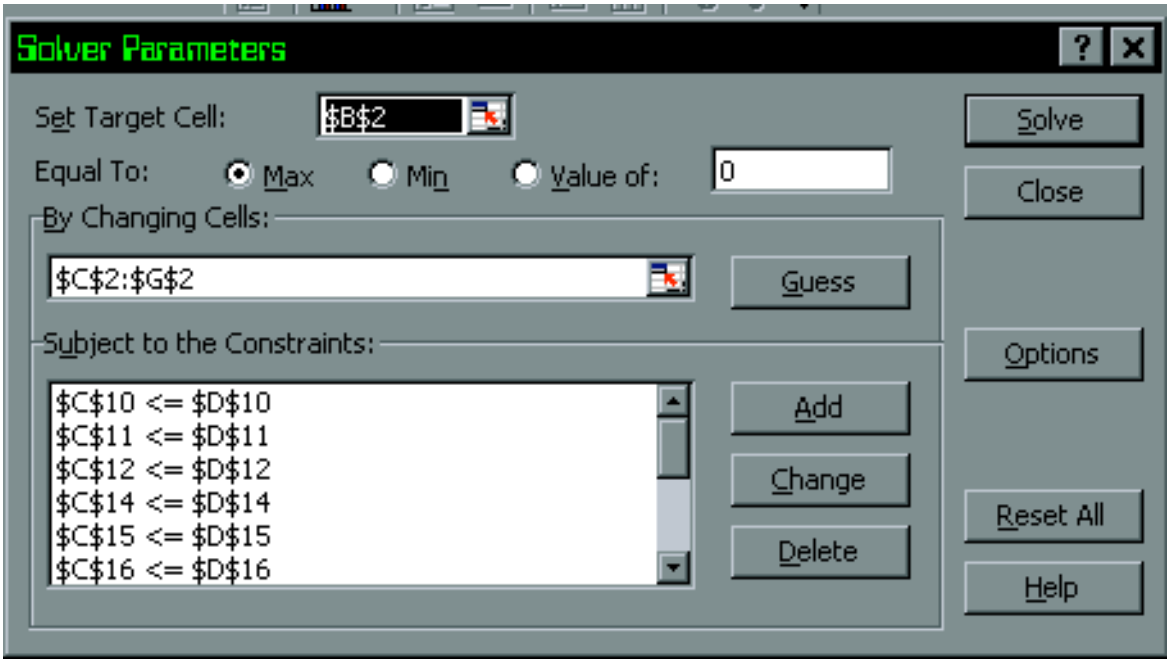
If **Solver** is not in the menu, you will have to go to >**Tools** >**Add-Ins** and install it. If it is not in the **Add-Ins** you will have to reinstall the data analysis pack that came with your software. Once in the above Solver menu, the target cell should say B2. Make sure **Equal to** is set at Max. Click below **By Changing Cells** and type in C2.G2**.** Click on **Add**. The following menu in Figure 14.6 should come up, which allows you to add in all your constraints.

Figure 14.6 Excel Solver Constraint Menu



Click on the empty box under **Cell Reference**. Type in or click on cell C4. Make sure the sign to the right of the cell reference is <=. If it is not, click next to it and select <=. Click below **Constraint**: and type in or select D4. Click on **OK.** Repeat the process for cells C5 and D5 and so on until all constraints are entered. Note it does not matter what order you enter your constraints. Your Solver parameter menu should look something like Figure 14.7.

Figure 14.7 Solver Menu for Refinery Problem



Once you have your model all set up, click on **Solve.** Solver will tell you if it can solve the problem or not. If it solves, the optimal crude use will be in cells C2.G2. How much product is produced will be in cells D4.D7.