

Using Solver to Maximize Resources

One of the key considerations for anyone involved in preparing revenue forecasts is to maximize profits, given available resources and operational and financial constraints. Constraints on profitability may take the form of distribution restrictions, production capacity limits, scarce inventory, or shortages of working capital caused by growth in accounts receivable or inventory. Whatever the nature of the constraints, it is the goal of every financial manager to find solutions that maximize the value of the organization. Excel's Solver add-in can assist in that process.

Solver is used to find optimal solutions to linear and non-linear programming models. For example, Solver can be used to maximize gross profits by calculating the optimal mix of products sold, minimize interest expense by finding an optimal capital structure for the company, or maximize production output by calculating the most efficient production runs. Regardless of the circumstances, Solver optimizes a value in one cell of a workbook by adjusting various input cells, subject to user-specified constraints placed on the input cells.

In this example, the CFO of a medical technology lab seeks to maximize the gross profit generated by a piece of testing equipment. The equipment can perform three different tasks, each with different billing rates, marginal costs, and gross profits. Further, the maximum number of units that can be sold of each procedure varies. The following table displays the relevant data:

	Task A	Task B	Task C
Billing Rate	\$350	\$250	\$200
Marginal Cost	\$175	\$50	\$100
Gross Profit Per Unit Sold	\$175	\$200	\$100
Max Number Of Sales Per Year	500 minus 1/2 of the instances of Tasks B and C sold for the year	500 minus 1/2 of the instances of Task C sold for the year	500

No more than 750 procedures in total can be sold during the year, and a minimum of 50 units of each procedure must be sold. Given these constraints, the CFO must calculate the optimal mix of sales units of each task in order to maximize overall gross profit. Using Solver, a solution for this complex revenue maximization model can be calculated in short order.

First, build the basic structure of the worksheet, as shown in **Figure 1** on the following page. The second panel in the figure displays the underlying formulas.

	A	B	C	D	E	F
1		Task A	Task B	Task C		
2	Maximum Number Available	500	500	500	Total Sold Cannot Exceed	750
3	Billing Rate	\$ 350.00	\$ 250.00	\$ 200.00		
4	Marginal Cost	\$ 175.00	\$ 50.00	\$ 100.00		
5	Gross Profit Per Unit	\$ 175.00	\$ 200.00	\$ 100.00		
6	Number Sold	-	-	-	Total Sold	-
7	Total Gross Profit	\$ -	\$ -	\$ -	Total Gross Profit	\$ -

	A	B	C	D	E	F
1		Task A	Task B	Task C		
2	Maximum Number Available	=500-(0.5*(D6+C6))	=500-(0.5*D6)	500	Total Sold Cannot Exceed	750
3	Billing Rate	350	250	200		
4	Marginal Cost	175	50	100		
5	Gross Profit Per Unit	=B3-B4	=C3-C4	=D3-D4		
6	Number Sold	0	0	0	Total Sold	=SUM(B6:D6)
7	Total Gross Profit	=B5*B6	=C5*C6	=D5*D6	Total Gross Profit	=SUM(B7:D7)

Figure 1 - Construct a Worksheet with the Appropriate Structure and Formulas

To begin the process of finding a solution, click **Solver** on the **Data** tab to open the **Solver Parameters** dialog box as shown in **Figure 2**. In the **Solver Parameters** dialog box, specify the target cell to be optimized (in this case F7), the variable cells to be adjusted (in this case, the range of cells B6:D6), and the relevant constraints, as previously described. Click the **Solve** button, and **Solver** will attempt to find a solution based on the input cells and constraints identified. When the results are calculated, select **Keep Solver Solution** in the **Solver Results** dialog box and click **OK**.

Solver Parameters

Set Target Cell: **\$F\$7**

Equal To: ☒ Max ☐ Min ☐ Value of: 0

By Changing Cells: **\$B\$6:\$D\$6**

Subject to the Constraints:

- \$B\$6 <= \$B\$2
- \$B\$6 >= 0
- \$B\$6 >= 50
- \$C\$6 <= \$C\$2
- \$C\$6 <= 50
- \$C\$6 >= 0

Buttons: Solve, Close, Guess, Options, Add, Change, Delete, Reset All, Help

Figure 2 - Specifying the Parameters for a Solver Optimization

The solution suggested by Solver is presented in **Figure 3**. Maximum profits are generated when 250 units of Task A, 50 units of Task B, and 450 units of Task C are sold. Closer inspection reveals that at least 50 units of each task are sold, that the total number of all tasks being sold is less than or equal to 750 units, and that the number of units of each task sold is less than or equal to the maximum number available.

	A	B	C	D	E	F
1	Task A Task B Task C					
2	Maximum Number Available	250	275	500	Total Sold Cannot Exceed	750
3	Billing Rate	\$ 350.00	\$ 250.00	\$ 200.00		
4	Marginal Cost	\$ 175.00	\$ 50.00	\$ 100.00		
5	Gross Profit Per Unit	\$ 175.00	\$ 200.00	\$ 100.00		
6	Number Sold	250	50	450	Total Sold	750
7	Total Gross Profit	\$43,750	\$ 10,000	\$45,000	Total Gross Profit	\$98,750

Figure 3 - Results of Solver Produced Profit Maximization

In addition to the computational efficiency of Solver, users can benefit from its documentation features in the form of several reports. The Solver Answer Report is shown in **Figure 4**.

	A	B	C	D	E	F	G
1	Microsoft Excel 12.0 Answer Report						
2	Worksheet: [Solver.xlsx]GP Maximization						
3	Report Created: 10/5/2008 5:10:48 PM						
4							
5							
6	Target Cell (Max)						
7		Cell	Name	Original Value	Final Value		
8		\$F\$7	Total Gross Profit	\$ 98,750	\$ 98,750		
9							
10							
11	Adjustable Cells						
12		Cell	Name	Original Value	Final Value		
13		\$B\$6	Number Sold Task A	250	250		
14		\$C\$6	Number Sold Task B	50	50		
15		\$D\$6	Number Sold Task C	450	450		
16							
17							
18	Constraints						
19		Cell	Name	Cell Value	Formula	Status	Slack
20		\$F\$6	Total Sold	750	\$F\$6<=\$F\$2	Binding	0
21		\$B\$6	Number Sold Task A	250	\$B\$6<=\$B\$2	Binding	0
22		\$C\$6	Number Sold Task B	50	\$C\$6<=\$C\$2	Not Binding	225
23		\$B\$6	Number Sold Task A	250	\$B\$6>=0	Not Binding	250
24		\$C\$6	Number Sold Task B	50	\$C\$6>=0	Not Binding	50
25		\$D\$6	Number Sold Task C	450	\$D\$6>=0	Not Binding	450
26		\$D\$6	Number Sold Task C	450	\$D\$6<=\$D\$2	Not Binding	50
27		\$D\$6	Number Sold Task C	450	\$D\$6>=50	Not Binding	400
28		\$C\$6	Number Sold Task B	50	\$C\$6<=50	Binding	0
29		\$B\$6	Number Sold Task A	250	\$B\$6>=50	Not Binding	200

Figure 4 - Answer Report Generated with a Solver Solution

In addition to Answer reports, Solver can also generate Sensitivity Analysis, and Limits reports. Further, Solver solutions can be saved as Scenarios and recalled later in Scenario Manager.