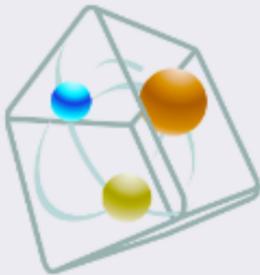


Works 2013



Optimization (sphere function)

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WHITEPAPER

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Chapter



1 About the whitepaper

1.1 Purpose

The purpose of this whitepaper is the optimization (minimization) of a simple problem represented by the well-known sphere function.

1.2 Software

In order to complete the example successfully, the following software is required:

- xlOptimizer v2.0.
- Microsoft Excel (version 2003 or newer).

Later versions of the aforementioned software may be incompatible with the structure of the example as it is presented herein.

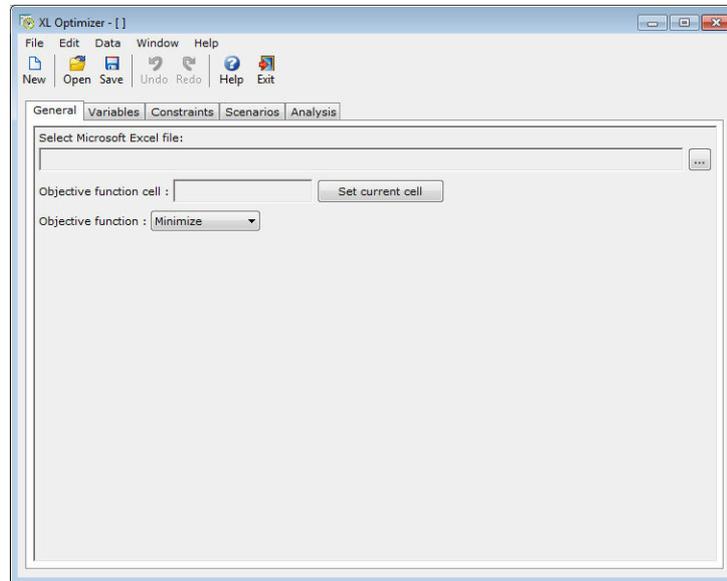
Chapter



2 Steps

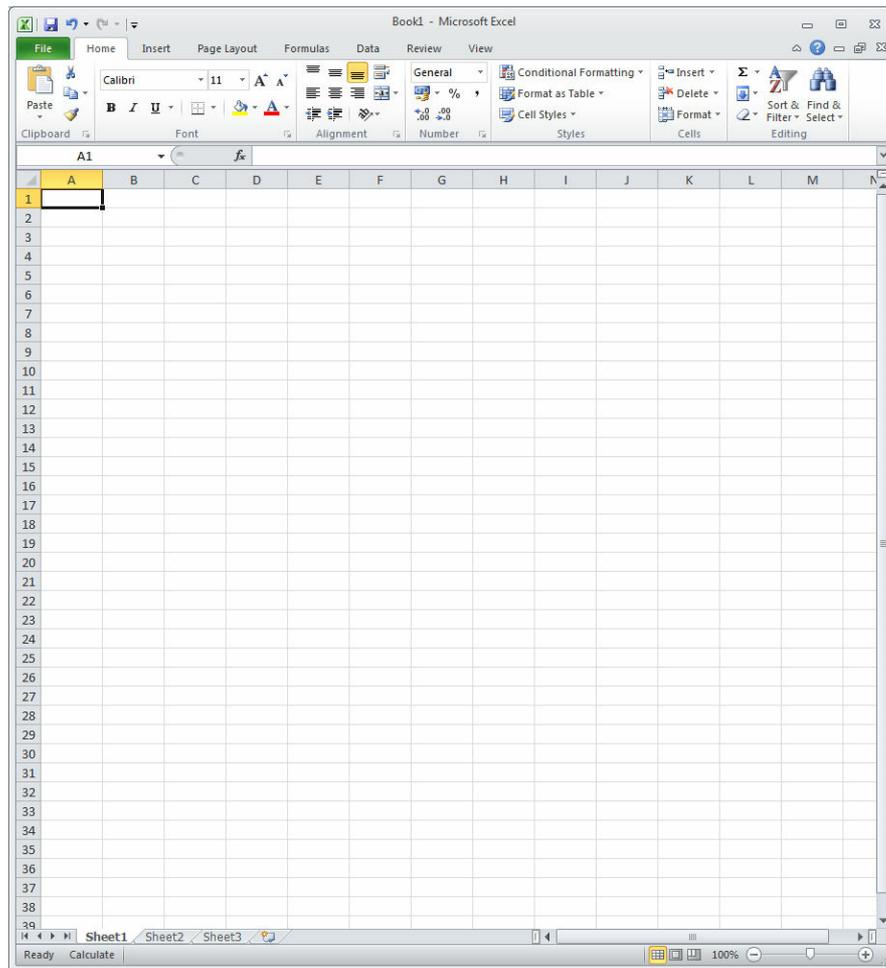
2.1 Step 01: New project

Select **New Project** from the **File** menu. The program will remove any data from memory and prepare to start a new project:



2.2 Step 02: Setting up the spreadsheet

We proceed to create the spreadsheet. Open Microsoft Excel (in the following images, version 2010 of Microsoft Excel is shown; the process is precisely the same with older versions):



Select a filename, e.g. Sample 1.xls and save it somewhere in your hard drive. It is very convenient to save both the project file (.m82) and the Microsoft Excel file (.xls or .xlsx) in the same path (although this is not mandatory).

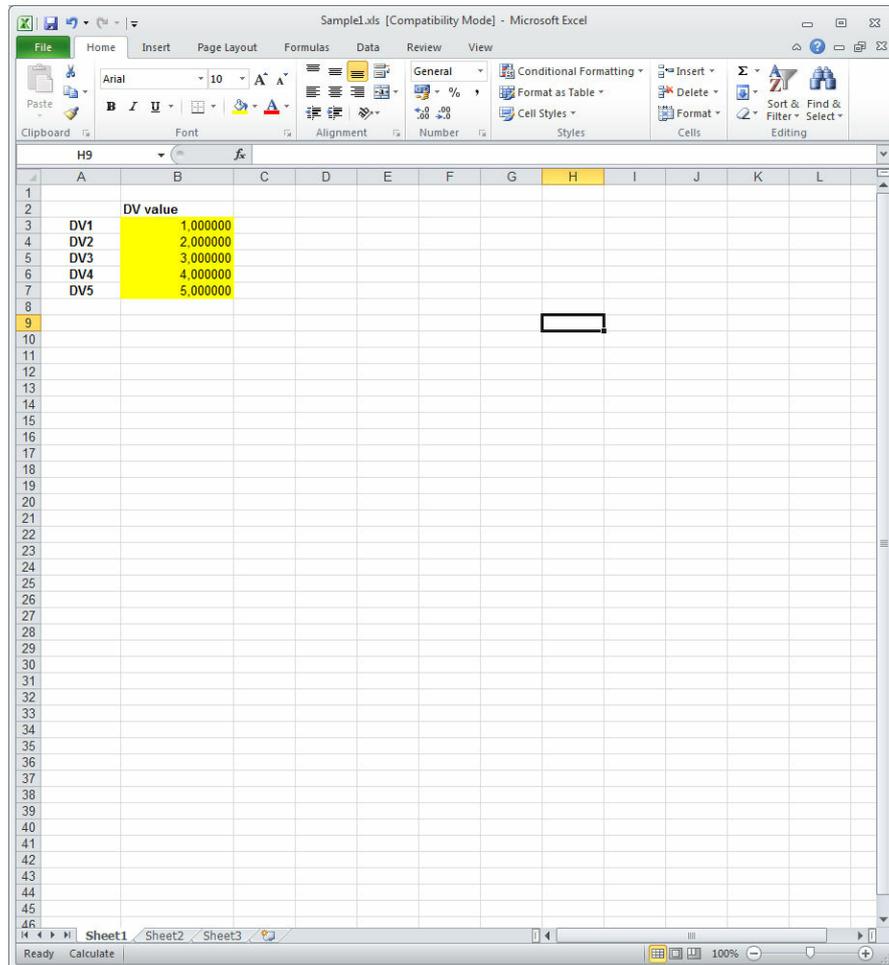
For optimization, it is important to define a suitable **objective function**. This objective function takes as arguments the values of the design variables and produces an output (a number) which is decisive as to if the proposed solution is "good" or "bad". A simple mathematical expression, which can be used as toy-problem, is the well known sphere function:

$$f(x_1, x_2, x_3, \dots, x_n) = x_1^2 + x_2^2 + x_3^2 + \dots + x_n^2 = \sum_{i=1}^n x_i^2$$

We assume that our problem has 5 variables, i.e. n=5, and each of them takes values in the range -10 to 10. We wish to minimize this expression. Due to the simple mathematical representation, we know a priori that the global optimum is zero, and occurs when all variables are equal to zero.

In Microsoft Excel, leave a line for the title, and create a column with the names of the design variables, e.g. DV1, DV2, ..., DV5. In the column on the right, enter their values (initial values are set equal to 1, 2, ..., 5 in the following image). Note that the

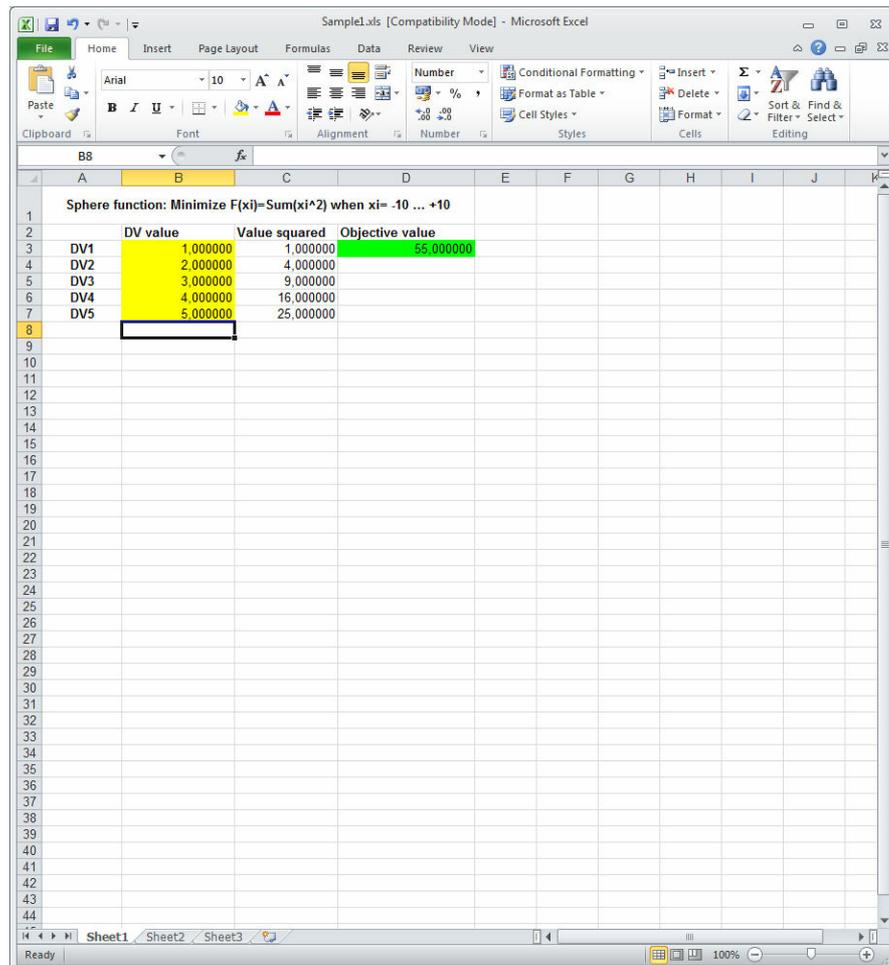
background of the cells is set to bright yellow to avoid confusion.



In the next column, enter a function which returns the square of the cell on the left, i. e. in cell C3, enter ' $=B3^2$ '. Extend this function to the other cells below.

Evaluate the sum of the squares in cell D3, by entering the expression ' $=SUM(C3:C7)$ '.

Add the titles, and set the background of cell D3 (the objective function) to green. The final image of the spreadsheet is as follows:



Sample1.xls [Compatibility Mode] - Microsoft Excel

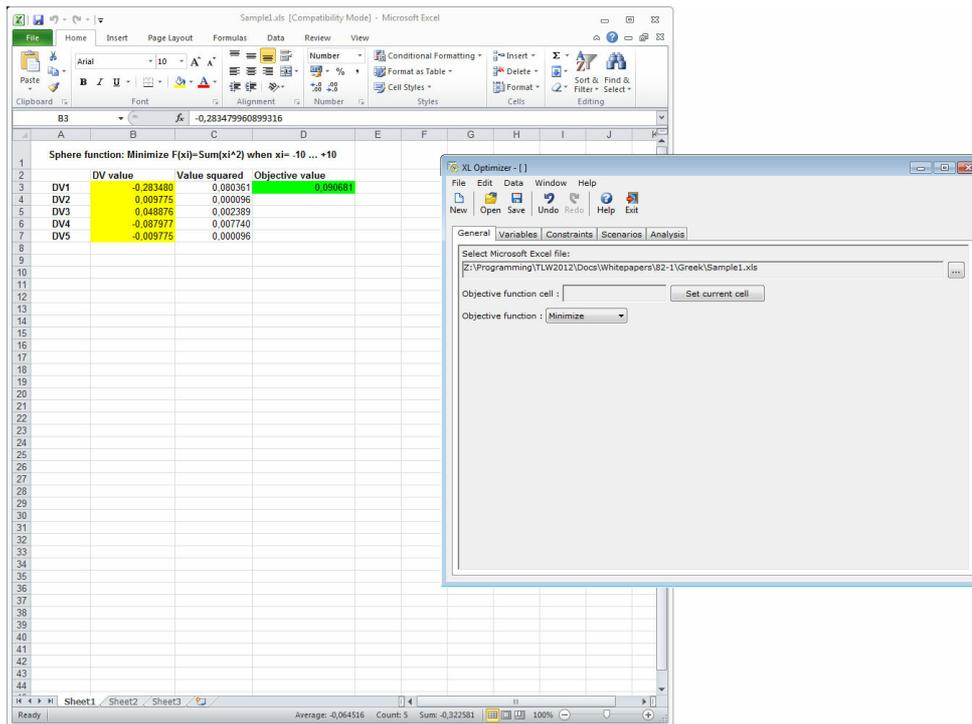
Sphere function: Minimize $F(x_i) = \text{Sum}(x_i^2)$ when $x_i = -10 \dots +10$

	DV value	Value squared	Objective value
DV1	1,000000	1,000000	56,000000
DV2	2,000000	4,000000	
DV3	3,000000	9,000000	
DV4	4,000000	16,000000	
DV5	5,000000	25,000000	

The spreadsheet is ready. Save the file and **close Microsoft Excel**.

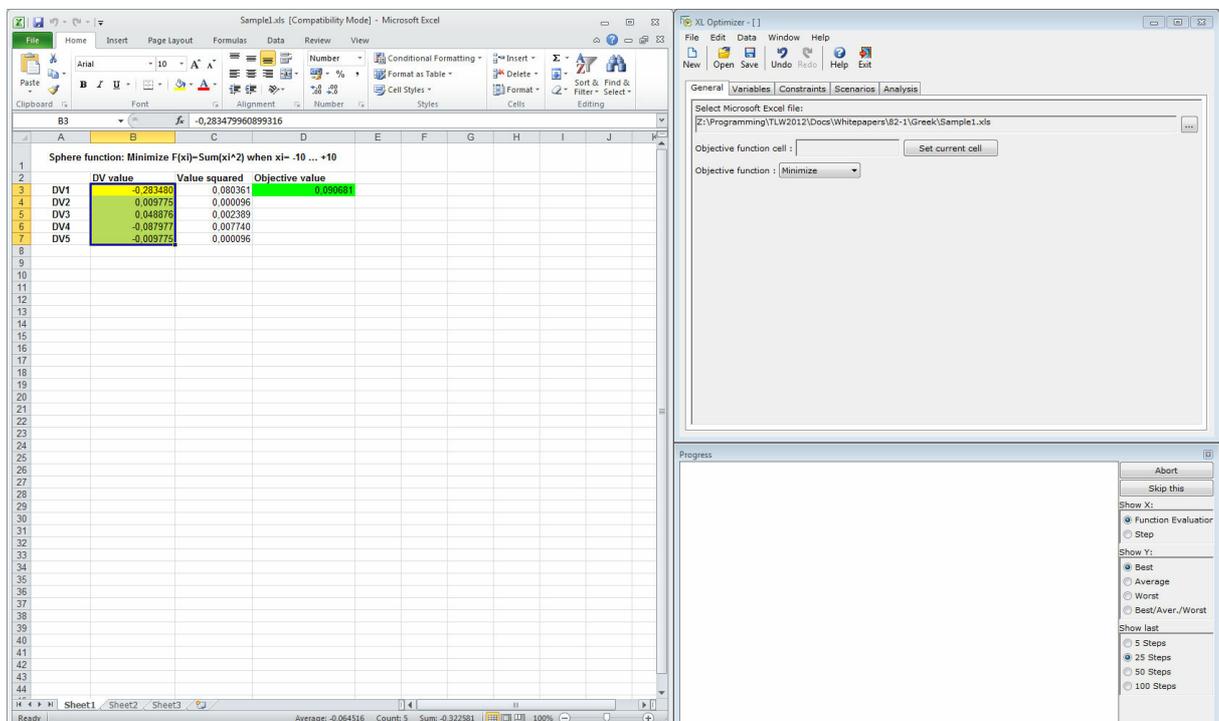
2.3 Step 03: Data input

We return to xOptimizer. Select the **General** tab. Click the button with the ellipses "...". in the **Select Microsoft Excel file:**. Select the spreadsheet file that you have created in the previous step. Press Ok and Microsoft Excel is loaded:



In xLOptimizer, select **Window > Status/Progress window** to view the status/progress window (if not already visible).

Also, select **Window > Auto-arrange** to arrange the windows automatically. The screen now looks like this:



We need to enter the cell that contains the objective function. In **Microsoft Excel**, **select cell D3 (only)**. Next, in xOptimizer click **Set current cell button**. As a result, the corresponding field is updated. When the mouse pointer is over the button, the background of the currently selected cell in Microsoft Excel is temporarily set to red (to avoid confusion).

In the **objective function** field, make sure that **minimize** is selected.

The screen now looks like this:

The screenshot shows two windows. On the left is Microsoft Excel with a spreadsheet titled 'Sample1.xls'. The spreadsheet contains the following data:

	DV value	Value squared	Objective value
3	DV1	1,000000	1,000000
4	DV2	2,000000	4,000000
5	DV3	3,000000	9,000000
6	DV4	4,000000	16,000000
7	DV5	5,000000	25,000000

On the right is the xOptimizer window. The 'General' tab is active. The 'Select Microsoft Excel File:' field contains 'Z:\Programming\TLW2012\Docs\Whitepapers\82-1\Greek\Sample1.xls'. The 'Objective function cell:' is set to 'Sheet1!\$D\$3'. The 'Objective function:' is set to 'Minimize'. The 'Progress' section is empty, and the 'Show last' section shows '5 Steps' selected.

In xOptimizer, select the **Variables** tab. In Microsoft Excel, select cells B3 to B7 (with the yellow background). In xOptimizer select **Data > Variables > Add**. The variables are added to the list:

The screenshot shows two windows. On the left is Microsoft Excel with a spreadsheet titled 'Sample.xls'. The spreadsheet contains the following data:

	DV value	Value squared	Objective value
3	DV1	1.000000	1.000000
4	DV2	2.000000	4.000000
5	DV3	3.000000	9.000000
6	DV4	4.000000	16.000000
7	DV5	5.000000	25.000000

On the right is the xLOptimizer window. It shows a table of variables:

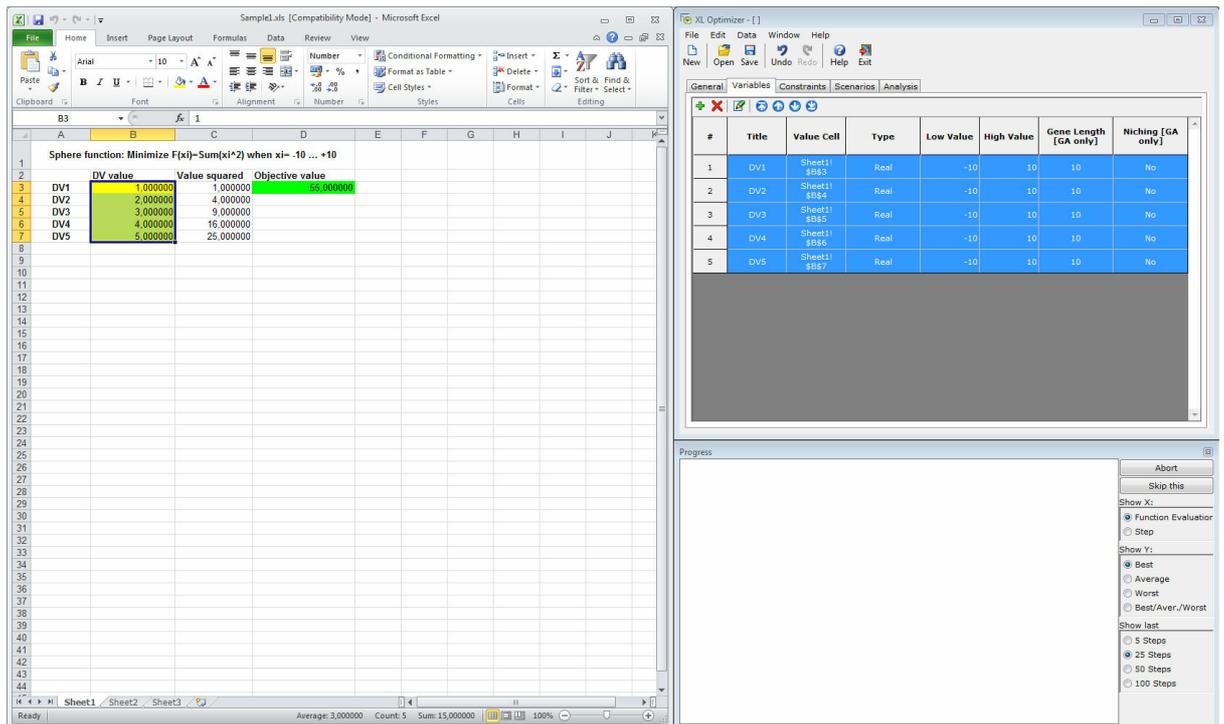
#	Title	Value Cell	Type	Low Value	High Value	Gene Length [GA only]	Niching [GA only]
1	DV1	Sheet1!\$B3	Real	0	1	10	No
2	DV2	Sheet1!\$B4	Real	0	1	10	No
3	DV3	Sheet1!\$B5	Real	0	1	10	No
4	DV4	Sheet1!\$B6	Real	0	1	10	No
5	DV5	Sheet1!\$B7	Real	0	1	10	No

We need to change the lower and upper boundaries of the variables. In xLOptimizer, select all rows (for all variables) and next select **Data > Variables > Properties**:

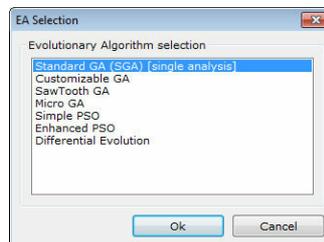
The 'Design Variable properties' dialog box is shown. It has the following settings:

- Title: Change, radio buttons for 'From cell on the left', 'From cell on the right', 'From cell above', 'From cell below', and 'Custom'. Variable: Variable: +
- Low value: Change,
- High value: Change,
- Gene length: Change,
- Niching: Change,
- Type: Change,

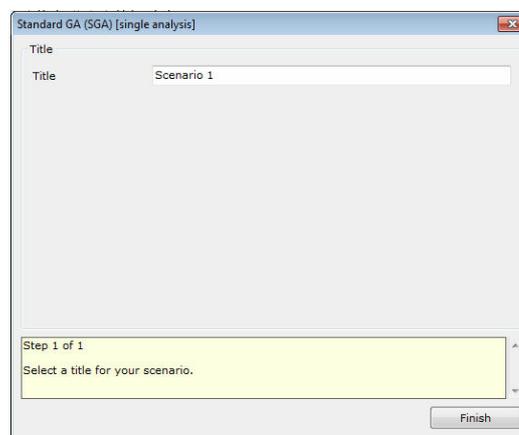
In the **Low value** field, change zero to -10. Make sure that the **Change** field is checked, so that the changes are actually applied to the variables. Also, change the **High value** from 1 to 10. Press **Ok** to close the form and apply the changes. The boundaries are now changed:



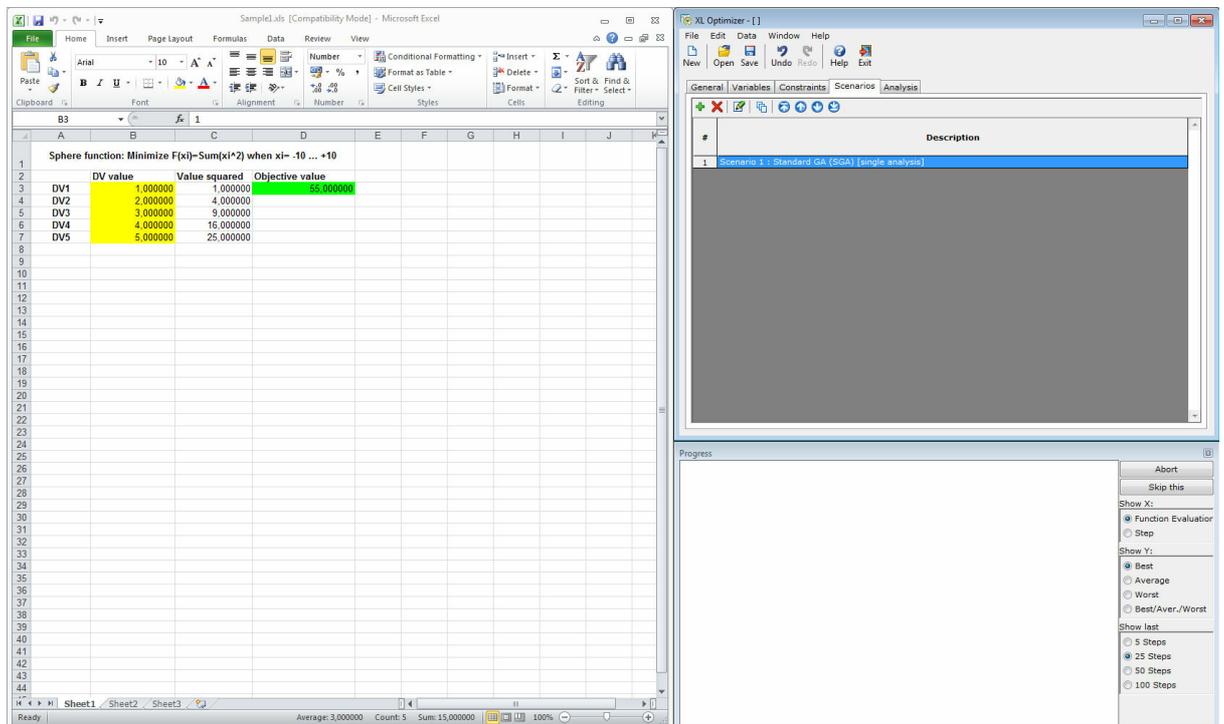
Finally, we will create a analysis scenario. In xLOptimizer, select the **Scenarios** tab. From the menu, select Scenarios > Add. The Evolutionary Algorithm selection form appears:



Select the first option, Standard GA [single analysis], and press **Ok**. The corresponding wizard appears:



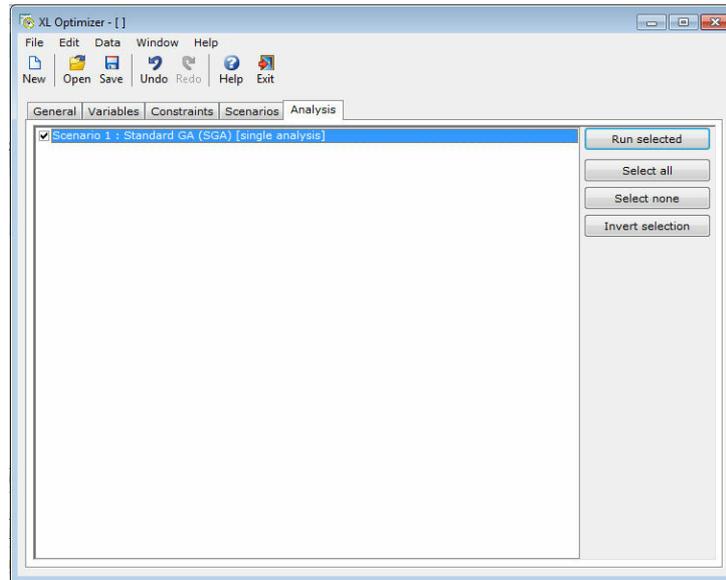
Leave the **Scenario 1** as the title of the scenario and press **Finish**. All other parameters are set automatically. The scenario is added to the list. The screen now looks like this:



The data input is now complete. From the menu, select **File > Save project as** and save the file, e.g. Sample1.m82 in the same path as Sample1.xls. We are now ready to proceed with optimization.

2.4 Step 04: Calculations

In this step, we will proceed with the optimization. In xLOptimizer, select the **Analysis** tab. Check the only scenario in the list:



Click the **Run selected** button. Optimization begins. In order to improve performance, the Microsoft Excel window is hidden. The status/progress window shows information on the progress. The analysis concludes after 20000 function evaluations or if you press the **Abort** button. In any case, Microsoft Excel window pops-up with the best solution that was found.

The screenshot displays the Microsoft Excel spreadsheet and the XL Optimizer progress window. The spreadsheet shows the results of the optimization for the Sphere function. The progress window shows a graph of Objective Value vs. Function Evaluations.

DV value	Value squared	Objective value
DV1	-0.127077	0.016149
DV2	0.048876	0.002389
DV3	0.009776	0.000096
DV4	0.244578	0.059721
DV5	-0.322581	0.104058

The progress window shows a graph of Objective Value vs. Function Evaluations. The Y-axis ranges from 0.000E+00 to 1.500E+00. The X-axis ranges from 400 to 1000. The graph shows a sharp decrease in the objective value around 600 function evaluations, reaching a minimum value of approximately 0.000E+00. The 'Best' solution is highlighted in red.

Chapter



3 Help

3.1 Technical support

Technical Support

TechnoLogismiki offers technical support 24 hours per day, 365 days per year, through the Web site where you can get information on the latest programs and services.

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- for questions regarding sales: sales@technologismiki.com
- for questions regarding the usage of programs: support@technologismiki.com
- for any other question or comment: info@technologismiki.com

The normal response time is within two business days. If your inquiry cannot be answered via e-mail, a customer service representative will contact you via telephone.

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Business days, 09:00 - 17:00 Eastern European Time:

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- FAX: ++30-210-654-8461
- Address: 5, Imittou str, Cholargos, 15561, Athens, Greece.