Chapter 9
Data Analysis

Using Scenarios, Goal Seek, Solver, Statistics, others
Copyright

This document is Copyright © 2020 by the LibreOffice Documentation Team. Contributors are listed below. You may distribute it and/or modify it under the terms of either the GNU General Public License (http://www.gnu.org/licenses/gpl.html), version 3 or later, or the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0/), version 4.0 or later.

All trademarks within this guide belong to their legitimate owners.

Contributors

This book is adapted and updated from the LibreOffice 6.2 Calc Guide.

To this edition
Steve Fanning Leo Moons

To previous editions
Barbara Duprey Jean Hollis Weber John A Smith
Kees Kriek Zachary Parliman Olivier Hallot
Steve Fanning

Feedback

Please direct any comments or suggestions about this document to the Documentation Team's mailing list: documentation@global.libreoffice.org.

Warning

Everything you send to a mailing list, including your email address and any other personal information that is written in the message, is publicly archived and cannot be deleted.

Publication date and software version

Published June 2020. Based on LibreOffice 6.4.

Using LibreOffice on macOS

Some keystrokes and menu items are different on macOS from those used in Windows and Linux. The table below gives some common substitutions for the instructions in this book. For a more detailed list, see the application Help and Appendix A (Keyboard Shortcuts) to this guide.

<table>
<thead>
<tr>
<th>Windows or Linux</th>
<th>macOS equivalent</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tools &gt; Options menu selection</td>
<td>LibreOffice &gt; Preferences</td>
<td>Access setup options</td>
</tr>
<tr>
<td>Right-click</td>
<td>Control+click and/or right-click depending on computer setup</td>
<td>Open a context menu</td>
</tr>
<tr>
<td>Ctrl (Control)</td>
<td>⌘ (Command)</td>
<td>Used with other keys</td>
</tr>
<tr>
<td>Ctrl+Q</td>
<td>⌘ + Q</td>
<td>Exit / quit LibreOffice</td>
</tr>
<tr>
<td>F11</td>
<td>⌘ + T</td>
<td>Open the Sidebar's Styles deck</td>
</tr>
</tbody>
</table>

Documentation for LibreOffice is available at https://documentation.libreoffice.org/en/
## Contents

Copyright ................................................................................................................. 2
Contributors .............................................................................................................. 2
To this edition .......................................................................................................... 2
To previous editions ............................................................................................... 2
Feedback .................................................................................................................. 2
Publication date and software version ................................................................. 2
Using LibreOffice on macOS .................................................................................... 2

### Introduction ........................................................................................................ 5

### Consolidating data ........................................................................................... 5
Consolidating data example .................................................................................... 6
Consolidation settings ............................................................................................ 6
Consolidation example ............................................................................................ 7

### Creating subtotals ............................................................................................ 8
Using the SUBTOTAL function .............................................................................. 8
A SUBTOTAL example .............................................................................................. 8
Using Data > Subtotals .......................................................................................... 11
Using the Subtotals tool ......................................................................................... 11
Subtotal outline ....................................................................................................... 12
Subtotals tool options ............................................................................................. 13
Reset and Remove .................................................................................................. 14

### Using scenarios ................................................................................................ 14
Creating scenarios ................................................................................................. 15
Scenario settings ................................................................................................... 16
Changing scenarios ............................................................................................... 17
Changing scenario properties ................................................................................ 17
Changing scenario cell values .............................................................................. 17
Working with scenarios using the Navigator ....................................................... 18

### Using the Multiple Operations tool ............................................................... 18
Multiple Operations with one formula and one variable ...................................... 19
An example with one formula and one variable ............................................... 19
Calculating with several formulas simultaneously .............................................. 21
An example with two formulas and one variable ............................................... 21
Multiple operations with two variables ............................................................... 23
Calculating with two variables ............................................................................. 23

### Using Goal Seek ............................................................................................... 24
Goal Seek example ................................................................................................. 25

### Using the Solver ............................................................................................... 26
Solver dialog ............................................................................................................ 27
Solver options ......................................................................................................... 29
Solver example ....................................................................................................... 29

### Using Statistics tools ...................................................................................... 30
Sampling tool ......................................................................................................... 31
Descriptive Statistics tool ..................................................................................... 32
Analysis of Variance (ANOVA) tool .......................................................... 34
Correlation tool ....................................................................................... 35
Covariance tool ....................................................................................... 36
Exponential Smoothing tool ................................................................... 37
Moving Average tool ............................................................................... 39
Regression tool ....................................................................................... 40
Paired T-test tool ...................................................................................... 43
F-test tool ................................................................................................ 45
Z-test tool ................................................................................................ 46
Test of Independence (Chi-Square) tool ................................................... 48
Fourier Analysis tool .............................................................................. 49
Introduction

Once you are familiar with functions and formulas, the next step is to learn how to use Calc’s automated processes to perform useful analysis of your data quickly.

In addition to formulas and functions, Calc includes several tools for processing your data. These tools include features for copying and reusing data, creating subtotals, running what-if analysis, and performing statistical analysis. They can be found under the Tools and Data menus in the Menu bar. While they are not necessary to using Calc, they can help you save time and effort with handling large data sets or preserving your work for future review.

Note

A related tool, the Pivot Table, is not mentioned here, as it is complex enough to require its own chapter. See Chapter 8, Using Pivot Tables, for more information.

Consolidating data

The Consolidate tool allows you to combine and aggregate data spread across one or more worksheets into one place. This tool is useful if you need to quickly summarize a large, scattered set of data for review. For example, you could use it to consolidate multiple department budgets from different worksheets into a single company-wide budget contained in a master worksheet.

To access the Consolidate tool dialog, select Data > Consolidate from the Menu bar (Figure 1).
Consolidating data example

To consolidate data:

1) Open the document containing the cell ranges to be consolidated.
2) Select Data > Consolidate from the Menu bar to open the Consolidate dialog (Figure 2).
3) Click on the Source data ranges field, then type a reference to a source data range, a named range or select it with the mouse. Use the associated Shrink / Expand button if you need to minimize the dialog while you select the range. Alternatively, select a named range from the drop-down list to the left of the field.
4) Click Add. The selected range is added to the Consolidation ranges list.
5) Repeat steps 3 and 4 to add additional source ranges.
6) To delete an entry in the Consolidation ranges list, select it and click Delete. The deletion is carried out without further confirmation.
7) Click on the Copy results to field, then type a reference to the first cell of the target range or select it with your mouse. You can also select a named range from the drop-down list to the left of the field.
8) Select a function to aggregate your data from the Function drop-down list. The default is Sum. Other available functions include Count, Average, Max, Min, Product, Count (numbers only), StdDev (sample), StDevP (population), Var (sample), and VarP (population).
9) Click OK to consolidate the ranges. Calc runs the function from step 8 on your source data ranges and populates the target range with the results.

Tip

If you are consolidating the same cell ranges repeatedly, consider converting them into reusable named ranges to make the process easier. For more information about named ranges, see Chapter 13, Calc as a Simple Database.

Consolidation settings

In the Consolidate dialog, click on the ‘+’ sign next to Options to access the following settings (Figure 2):

![Options](Figure 2: Consolidate tool options)

**Consolidate by**

In this section, choose whether to consolidate your source data ranges by their range position or by matching labels. Consolidation labels must be contained within each range, and the text of corresponding row or column labels must match for the rows or columns themselves to be combined.

- **Row labels** – Consolidates rows by matching label. If this option is unchecked, the tool will consolidate rows by position instead.
- **Column labels** – Works the same as Row labels, but with columns instead.
Options
In this section, select **Link to source data** to add formulas in the target range that link back to values in the source ranges. When you select this option, any changes you make in the source ranges will automatically update values in the target range.

Note
If you use the **Link to source data** option, each source link is inserted into the target range, then ordered and hidden from view. Only the final results of consolidation are displayed by default.

Consolidation example
Figures 3, 4, and 5 show a simple example of consolidation using a spreadsheet with the worksheets *Year 1*, *Year 2*, and *Consolidated Sales*. Figure 3 shows the contents of the *Year 1* worksheet, with sales figures by region for each of the four product colors.

![Figure 3: Year 1 sales by region](image)

Figure 4 shows the *Year 2* worksheet, sales figures by region for each of four product colors. Note the different ordering of row and column labels between the two figures.

![Figure 4: Year 2 sales by region](image)

Figure 5 shows the consolidated sales data, created by using the Consolidate dialog settings shown in Figure 2. Note that because the **Link to source data** option was selected, clicking on the plus sign (+) indicators to the left of the data will reveal formula links back to the source ranges.
The source ranges and target range are saved as part of the document. If you later open a document with consolidated ranges, they will still be available in the Consolidation ranges list of the Consolidate dialog.

Creating subtotals

Calc offers two methods of creating subtotals: the SUBTOTAL function and the Subtotals tool.

Using the SUBTOTAL function

The SUBTOTAL function is listed under the Mathematical category of the Function Wizard, and the Functions List deck of the Sidebar, which are described in Chapter 7, Using Formulas and Functions. SUBTOTAL is a relatively limited method for generating a subtotal, and works best if used with only a few categories.

A SUBTOTAL example

To illustrate how to use the SUBTOTAL function, we use the sales data worksheet shown in Figure 6. The AutoFilter function is already applied to the sales data, and are indicated by the down arrow buttons at the head of each column. AutoFilters are described in Chapter 2, Entering, Editing, and Formatting Data.

To create a summation subtotal for the Sales Value field:

1) Select the cell to contain a subtotal. Typically, this cell is at the bottom of the column being subtotaled, which, for our example, is the Sales Value column.

2) Use one of the following methods to open the Function Wizard dialog:
   - The Function Wizard icon from the Formula bar
   - Insert > Function from the Menu bar
   - Ctrl+F2 key combination
3) Select SUBTOTAL from the Function list in the Function Wizard dialog and click Next.

4) Enter the numeric code of a function into the Function field of the dialog. This code must be a value in the range 1 to 11 or 101 to 111, with the meaning of each value shown in Table 1.

Note

Values 1 to 11 include hidden values in the calculated subtotal, while values 101 to 111 do not. Hiding and showing data is described in Chapter 2, Entering, Editing, and Formatting Data. Filtered-out cells are always excluded by the SUBTOTAL function.

Table 1: SUBTOTAL function numbers

<table>
<thead>
<tr>
<th>Function index (includes hidden values)</th>
<th>Function index (ignores hidden values)</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>101</td>
<td>AVERAGE</td>
</tr>
<tr>
<td>2</td>
<td>102</td>
<td>COUNT</td>
</tr>
<tr>
<td>3</td>
<td>103</td>
<td>COUNTA</td>
</tr>
<tr>
<td>4</td>
<td>104</td>
<td>MAX</td>
</tr>
<tr>
<td>5</td>
<td>105</td>
<td>MIN</td>
</tr>
<tr>
<td>6</td>
<td>106</td>
<td>PRODUCT</td>
</tr>
<tr>
<td>7</td>
<td>107</td>
<td>STDEV</td>
</tr>
<tr>
<td>8</td>
<td>108</td>
<td>STDEVP</td>
</tr>
<tr>
<td>9</td>
<td>109</td>
<td>SUM</td>
</tr>
<tr>
<td>10</td>
<td>110</td>
<td>VAR</td>
</tr>
<tr>
<td>11</td>
<td>111</td>
<td>VARP</td>
</tr>
</tbody>
</table>

5) Click on the Range field, then type a reference to the Sales Value range or select the cells with your mouse (Figure 7). Use the Shrink / Expand button if you need to temporarily minimize the dialog while selecting the cells.

6) Click OK to close the Function Wizard dialog. The cell you selected in step 1 now contains the total sales value.

7) Click on the AutoFilter down arrow button at the top of the Employee column and remove all marks from the Standard Filter area except those next to Brigitte and (empty). The cell that you selected in step 1 should now reflect the sum of all of Brigitte’s sales (Figure 8).

Note

If the cell range used to calculate a subtotal contains other subtotals, these subtotals will not be counted in the final one. Similarly, if you use this function with AutoFilters, only the data satisfying the current filter selections will be displayed. Any filtered-out data is ignored.
Using Data > Subtotals

Calc offers the Subtotals tool as a more comprehensive alternative to the SUBTOTAL function. In contrast to SUBTOTAL, which only works on a single array, the Subtotals tool can create subtotals for up to three arrays arranged in labeled columns. It also groups subtotals by category and sorts them automatically, thereby eliminating the need to apply AutoFilters and filter categories by hand.

To use this tool, select **Data > Subtotals** from the Menu bar, which opens the Subtotals dialog.
Using the Subtotals tool
To insert subtotal values into a worksheet:

1) Select the cell range for the subtotals that you want to calculate, and remember to include the column heading labels. Alternatively, click on a single cell within your data to allow Calc to automatically identify the range.

2) Select Data > Subtotals from the Menu bar to open the Subtotals dialog (Figure 9).

3) In the Group by drop-down list on the 1st Group tab, select a column by its label. Entries in the cell range from step 1 will be grouped and sorted by matching values in this column.

4) In the Calculate subtotals for box on the 1st Group tab, select a column containing values to be subtotaled. If you later change values in this column, Calc will automatically recalculate the subtotals.

5) In the Use function box on the 1st Group tab, select a function to calculate the subtotals for the column selected in step 4.

6) Repeat steps 4 and 5 to create subtotals for other columns on the 1st Group tab.

7) You can create two more subtotal categories by using the 2nd Group and 3rd Group tabs and repeating steps 3 to 6. If you do not want to add more groups, then leave the Group by list for each page set to "- none -".

8) Click OK. Calc will add subtotal and grand total rows to your cell range.

For our sales data example, a partial view of the results is shown in Figure 10. The group settings are identified in Table 2.
Table 2: Group settings used on Subtotals dialog for example sales data

<table>
<thead>
<tr>
<th>Tab</th>
<th>Group by</th>
<th>Calculate subtotals for</th>
<th>Use function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Group</td>
<td>Employee</td>
<td>Sales Value</td>
<td>Sum</td>
</tr>
<tr>
<td>2nd Group</td>
<td>Category</td>
<td>Sales Value</td>
<td>Sum</td>
</tr>
<tr>
<td>3rd Group</td>
<td>- none -</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**Subtotal outline**

When you use the Subtotals tool, Calc inserts an outline to the left of the row number column. This outline represents the hierarchical structure of your subtotals, and can be used to hide or show data at different levels in the hierarchy using the numbered column indicators at the top of the outline or the group indicators, denoted by plus (+) and minus (-) signs.

This feature is useful if you have many subtotals, as you can simply hide low-level details, such as individual entries, to produce a high-level summary of your data. For more information on how to use outlines, see Chapter 2, Entering, Editing, and Formatting Data.

To turn off outlines, select Data > Group and Outline > Remove Outline from the Menu bar. To reinstate them, select Data > Group and Outline > AutoOutline.

Figure 10 shows the outline for our sales data example.

![Figure 10: Partial outlined view of sales data example with subtotals](image-url)
Column 1 represents the highest group level, the grand total over all employees. Columns 2 to 5 show descending group levels as follows:

- Column 2 represents the grand total over all categories.
- Column 3 represents the total for each employee.
- Column 4 represents the total for each category for an individual employee.
- Column 5 shows individual entries.

**Subtotals tool options**

Click on the *Options* tab of the Subtotals dialog to access the following settings:

**Groups**

Defines how subtotal data is organized.

- **Page break between groups** – inserts page breaks between each subtotal group so that each group displays on a separate page when you print the data.
- **Case sensitive** – prevents the tool from grouping entries by data labels that differ by case. In our sales data example, entries with "Brigitte" and “brigitte” under the Employee column will not match if this option is selected.
- **Pre-sort area according to groups** – sorts entries by group before calculating subtotals. Disabling this option prevents the tool from grouping matching entries together. As a result, distinct subtotals will be created for matching entries if they do not appear on consecutive rows. For example, two entries under the “Golf” category will not count towards the same group subtotal if there is an entry for “Tennis” in between them.

**Sort**

Defines how subtotal data is sorted. This section is disabled if **Pre-sort area according to groups** is unchecked.

- **Ascending** or **Descending** – sorts entries by value from lowest to highest and highest to lowest, respectively. You can modify these sort rules by using *Data > Sort* in the Menu bar. For more detail, see Chapter 2, Entering, Editing, and Formatting Data.
- **Include formats** – carries over formatting, such as the currency format, from the data to the corresponding subtotals.
- **Custom sort order** – sorts your data according to one of the predefined custom sorts defined in *Tools > Options > LibreOffice Calc > Sort Lists* in the Menu bar. For more
details about custom sort lists, see Chapter 2, Entering, Editing, and Formatting Data.

**Reset and Remove**

In the Subtotals dialog, use the **Reset** button to undo any changes made on the current tab page. Use the **Remove** button to remove any subtotals that have already been created using the Subtotals tool. Use these features with care, as no confirmation dialogs will be displayed.

**Using scenarios**

Scenarios are saved, named cell ranges that you can use to answer “what-if” questions about your data. You can create multiple scenarios for the same calculation set, then quickly swap between them to view the outcomes of each. This feature is useful if you need to test the effects of different conditions on your calculations, but do not want to deal with repetitive manual data entry. For example, if you wanted to test different interest rates for an investment, you could create scenarios for each rate, then switch between them to find out which rates work the best for you.

To use the Scenarios tool, select **Tools > Scenarios** from the Menu bar to open the Create Scenario dialog (Figure 12).

![Create Scenario dialog](image)

**Creating scenarios**

To create a new scenario:

1) Select the cells that contain the values that will change between scenarios. To select multiple ranges, hold down the *Ctrl* key as you click. You must select at least two cells.

2) Choose **Tools > Scenarios** from the Menu bar to open the Create Scenario dialog.

3) Enter a name for the new scenario in the **Name of Scenario** field.
Tip

For each scenario you create, use a unique name that clearly identifies and distinguishes it. This practice will save you time and headache if you have to work with a large set of scenarios.

4) Optionally, add information to the *Comment* field. The example in Figure 12 shows the default comment.

5) Click **OK** to close the dialog. The new scenario is automatically activated upon creation.

6) Repeat steps 1 to 5 to create additional scenarios. Select the same cell range that you used for the first scenario to have multiple scenarios for the same calculations.

**Tip**

To keep track of what calculations are dependent on your scenarios, use **Tools > Detective > Trace Dependents** from the Menu bar on your scenario cells. Arrows will point from your scenario cells to the dependent formula cells. For more information about the Detective tool, see Chapter 7, Using Formulas and Functions.

### Scenario settings

The *Settings* sections of the Create Scenario dialog contains the following options:

![Create Scenario settings](image)

**Display border**

Places a colored border around the cell range that contains your scenario (Figure 14).

![Scenario cell range with border](image)

To choose the color of the border, use the drop-down field to the right of this option. The border has a title bar displaying the name of the active scenario and a down arrow button.
that opens a drop-down list of all the scenarios defined for the current cell range. You can swap to a scenario by selecting it from this list.

**Copy back**
Copies any changes made to a scenario's cell values back into the active scenario. If you uncheck this option, then the scenario's initial values cannot be overwritten. The actual behavior of the **Copy back** setting depends on the current cell and sheet protections and the **Prevent changes** setting (see Table 4 on page 17).

![Caution]

When creating a new scenario from the cells of a scenario with **Copy back** enabled, be careful not to overwrite the old scenario. To avoid this situation, create the new scenario with **Copy back** enabled first, then change its values only once it is active.

**Copy entire sheet**
Creates a copy of the sheet with the new active scenario. The sheet is named after this scenario. Note that changing scenario values in the copy sheet will not affect the active scenario, even if it has **Copy back** enabled.

**Prevent changes**
Prevents changes to a scenario with **Copy back** enabled when the sheet is protected but the cells are not. Also prevents changes to the scenario's settings while the sheet is protected. This option and its effects are more fully explained in the next section.

**Changing scenarios**
Scenarios have two aspects that can be altered independently:

- Scenario properties (that is, its settings)
- Scenario cell values

The extent to which these aspects can be changed depends on the active scenario's properties and the current sheet and cell protections. For more detail about sheet and cell protections, see Chapter 2, Entering, Editing, and Formatting Data.

**Changing scenario properties**
Table 3 summarizes how sheet protection and the **Prevent changes** option affect your ability to change scenario properties.

*Table 3: Changing scenario properties*

<table>
<thead>
<tr>
<th>Sheet protection</th>
<th>Prevent changes</th>
<th>Property changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>On</td>
<td>On</td>
<td>No scenario properties can be changed.</td>
</tr>
<tr>
<td>On</td>
<td>Off</td>
<td><strong>Display border</strong> and <strong>Copy back</strong> can be changed. <strong>Prevent changes</strong> and <strong>Copy entire sheet</strong> cannot be changed.</td>
</tr>
<tr>
<td>Off</td>
<td>Any setting</td>
<td>All scenario parameters except for <strong>Copy entire sheet</strong> can be changed. In this case, the <strong>Prevent changes</strong> option has no effect.</td>
</tr>
</tbody>
</table>

**Changing scenario cell values**
Table 4 summarizes the interaction of various settings in making changes to scenario cell values.
Table 4: Changing scenario cell values

<table>
<thead>
<tr>
<th>Sheet protection</th>
<th>Scenario cell protection</th>
<th>Prevent changes</th>
<th>Copy back</th>
<th>Change allowed</th>
</tr>
</thead>
<tbody>
<tr>
<td>On</td>
<td>Off</td>
<td>On</td>
<td>On</td>
<td>Scenario cell values cannot be changed.</td>
</tr>
<tr>
<td>On</td>
<td>Off</td>
<td>Off</td>
<td>On</td>
<td>Scenario cell values can be changed, and the scenario is updated.</td>
</tr>
<tr>
<td>On</td>
<td>Off</td>
<td>Any setting</td>
<td>Off</td>
<td>Scenario cell values can be changed, but the scenario is not updated due to the Copy back setting.</td>
</tr>
<tr>
<td>Off</td>
<td>Any setting</td>
<td>Any setting</td>
<td>Any setting</td>
<td>Scenario cell values can be changed and the scenario is updated or not, depending on the Copy back setting.</td>
</tr>
</tbody>
</table>

Working with scenarios using the Navigator

After you add scenarios to a spreadsheet, you can view a particular scenario by using the Navigator. Open it by selecting View > Navigator from the Menu bar, then click on the Scenarios icon in the Navigator and select a scenario from the list (Figure 15). Any defined scenarios are listed along with the comments that were entered when each scenario was created. For more information about the Navigator, see Chapter 1, Introduction.

To apply a scenario to the current sheet, double-click the scenario name in the Navigator.

To delete a scenario, right-click the name in the Navigator and choose Delete. A confirmation dialog will be displayed.
To edit a scenario, right-click the name in the Navigator and choose Properties. Calc displays the Edit Scenario dialog, which is similar to the Create Scenario dialog (Figure 12).

**Using the Multiple Operations tool**

Like scenarios, the Multiple Operations tool performs what-if analysis on your calculations. Unlike scenarios, which represent individual sets of values for multiple formula variables, this tool uses a whole range of values for just one or two variables. It then uses one or more formulas to create a matching range of solutions. Since each solution corresponds to one or two variable values, both the variable and solution ranges can be easily arrayed in tabular format. As a result, the Multiple Operations tool is well-suited to generating data that easy to read and share or visualize using graphs.

**Tip**

Exercising good organization can make using this tool relatively painless. For example, we recommend keeping your data together on one sheet and using labels to identify your formulas, variables, and table ranges.

To use this tool, select Data > Multiple Operations from the Menu bar to open the Multiple Operations dialog (Figure 16).

![Figure 16: Multiple Operations dialog](image)

**Multiple Operations with one formula and one variable**

The easiest way to learn how to use the Multiple Operations tool is with one formula and one variable. To learn how to use the tool with multiple formulas or with two variables, see “Calculating with several formulas simultaneously” (page 20) and “Multiple operations with two variables” (page 22), respectively.

To use the Multiple Operations tool with one formula and one variable:

1) In the cells of a worksheet, enter a formula and at least one variable that it uses.

2) In the same worksheet, enter values into a cell range that occupies a single column or row. These values will be used for one of the variables of the formula that you defined in step 1.

3) With the mouse, select the range containing both the variable range that you defined in step 2 and the adjacent empty cells that follow it. Depending on how your variable range is arrayed, these empty cells will either be in the column to the right (if the range is in a column) or in the row immediately below (if it is in a row).

4) Select Data > Multiple Operations to open the Multiple Operations dialog.
5) Click on the *Formulas* field and type a cell reference to the formula you defined in step 1 or select the cell with the mouse. Use the associated *Shrink / Expand* button if you need to minimize the dialog while selecting the cell.

6) If the range from step 2 is arrayed in a column, then click on the *Column input cell* field and type a cell reference to the variable that you want to use or select the cell with the mouse. If the range is in a row, then use the *Row input cell* field instead.

7) Click **OK** to run the tool. The Multiple Operations tool will generate its results in the empty cells that you selected in step 3. Each result value corresponds to the variable value adjacent to it, and together they form the entries of a results table.

### An example with one formula and one variable

Using the Multiple Operations tool is best explained by example. Suppose that you produce toys that you sell for $10 each (cell B1 of a worksheet). Each toy costs $2 to make (B2), and you have a fixed annual cost of $10,000 (B3). What is the minimum number of toys that you must sell to break even? Suppose that our initial estimate of quantity sold is 2,000 (B4).

To answer this question:

1) Enter the following formula into B5: `=B4*(B1-B2) - B3`. This formula represents the equation *Profit = Quantity \* (Selling price – Direct costs) – Fixed costs*. With this equation, our initial quantity produces a $6,000 profit, which is higher than the break-even point.

2) In D2:D11, enter a range of alternate quantities from **500** to **5000** in steps of **500**.

3) Select the range D2:E11 to define the results table. This range includes the alternate quantity values (column D) and the empty results cells (column E).

4) Select **Data > Multiple Operations** to open the Multiple Operations dialog.

5) Using the *Formulas* field, select the cell B5.

![Figure 17: Inputs to Multiple Operations tool for one formula, one variable](image)
6) Using the Column input cell field, select the cell B4 to set the quantity as the variable for our calculations. Figure 17 shows the worksheet and Multiple Operations dialog at this point.

7) Click OK. The profits for the different quantities are now shown in column E (Figure 18). We can see that the break-even point is between 1000 and 1500 toys sold – namely, 1250.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unit sale price</td>
<td>$10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Unit cost</td>
<td>$2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Fixed annual cost</td>
<td>$10,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Quantity sold</td>
<td>2,000</td>
<td>1500</td>
<td>$2,000</td>
</tr>
<tr>
<td>5</td>
<td>Profit</td>
<td>$6,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>2500</td>
<td>$10,000</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>3000</td>
<td>$14,000</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>3500</td>
<td>$18,000</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>4000</td>
<td>$22,000</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>4500</td>
<td>$26,000</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5000</td>
<td>$30,000</td>
<td></td>
</tr>
</tbody>
</table>

Figure 18: Results of Multiple Operations tool for one formula and one variable

Profit over quantity

![Profit over quantity graph](image)

Figure 19: XY scatterplot of profit over quantity of toys sold (example of visualization)

Calculating with several formulas simultaneously

Using the Multiple Operations tool with multiple formulas follows nearly the same process as with one formula, but with two important differences:

1) For each formula that you add, you must also add a corresponding column or row to the results table to contain the output of that formula.

2) How you initially arrange your formulas determines how their results will be displayed in the results table. For example, if you arrange the formulas A, B, and C in a single row in that order, then Calc will generate the results of A in the first results table column, the results of B in the second column, and the results of C in the third.

Note
The Multiple Operations tool only accepts formulas arranged in a single row or column, depending on how your results table is oriented. If the table is column-oriented — that is, the way it is in our sales data example — then your formulas must be arranged in a row. If the table is row-oriented, then your formulas must be in a column.

**Caution**

Be careful not to add empty cells between formulas, as they will create gaps in the results table and may cause some results not to appear if you don’t select enough rows or columns for the table.

**An example with two formulas and one variable**

Using our sales data example, suppose that we want to calculate the annual profit per item sold in addition to the annual overall profit. To calculate the results:

1) In the sheet from the previous example, delete the results in column E.
2) Enter the following formula in C5: =B5/B4. You are now calculating the annual profit per item sold.
3) Select the range D2:F11 for the results table. Column F will contain the results of the annual profit per item formula in C5.
4) Select **Data > Multiple Operations** from the Menu bar to open the Multiple Operations dialog.
5) Using the **Formulas** field, select the range B5:C5.
6) Using the **Column input cell** field, select the cell B4. Figure 20 shows the worksheet and the dialog at this point.

![Figure 20: Inputs to Multiple Operations tool for one variable and two formulas](image)

7) Click **OK**. Now the profits are listed in column E and the annual profit per item in column F.

---

**Calculating with several formulas simultaneously**
Multiple operations with two variables

When you use the Multiple Operations tool with two variables, it creates a two-dimensional results table. Each variable defines one of the table’s dimensions such that the alternate values for both variables serve as the table’s row and column headings, respectively. Each cell in the table corresponds to a distinct pair of row and column heading values. In turn, the results in each cell are created from these values for both variables.

Since you are using two variables, you must use both the Column input cell and Row input cell dialog fields to define them. The order is important; the Column input cell field corresponds to the row heading values, while the Row input cell field corresponds to the column heading values.

**Tip**

A good guideline to remember is that since column headings are in a row at the top of the table, they correspond to the Row input cell field. Likewise, row headings are in a column, so they correspond to the Column input cell field.

**Note**

If you use two variables, the Multiple Operations tool will not work with multiple formulas. It will allow you to enter the extra formulas, but will not generate the expected results for any formula beyond the first.

**Calculating with two variables**

Using our sales example, suppose that in addition to varying the quantity of toys sold, you also want to vary the unit sale price as well. To calculate the results:

1) Expand the sales data table by entering $8, $10, $15 and $20 in the range E1:H1.
2) Select the range D1:H11 for the results table.
3) Select Data > Multiple Operations from the Menu bar to open the Multiple Operations dialog.
4) Using the Formulas field, select cell B5.
5) Using the Row input cell field, select cell B1. The column headings – $8, $10, $15 and $20 – are now linked to the unit sale price variable defined in cell B1.
6) Using the *Column input cell* field, select cell B4. The row headings – 500, 1000, ..., 5000 – are now linked to the quantity sold variable defined in cell B4. Figure 22 shows the worksheet and dialog at this point.

7) Click **OK**. The profits for the different sale prices and quantities are now shown in the range E2:H11 (Figure 23).

---

![](image)

Figure 22: Inputs to Multiple Operations tool for two variables

![](image)

Figure 23: Results of Multiple Operations tool for two variables

---

**Using Goal Seek**

In addition to scenarios and the Multiple Operations tool, Calc has a third “what-if” analysis tool: Goal Seek. Usually, you use a formula to calculate a result from existing values. In contrast, with Goal Seek, you work backwards from a result to discover what values produce it. This feature is useful if you already know the outcome you want, but need to answer questions such as how to reach it or how it could be changed if you altered conditions.

To use this tool, select **Tools > Goal Seek** from the Menu bar to open the Goal Seek dialog (Figure 24).
Only one argument can be altered at a time in a single goal seek. If you need to test multiple arguments, then you must run a separate goal seek on each one.

**Goal Seek example**

To illustrate how to use Goal Seek, suppose that we want to calculate the annual interest return for an account. To calculate annual interest ($I$), we must create a table with values for the capital ($C$), the interest period length in years ($n$), and the interest rate ($i$). The formula is $I = C \times n \times i$.

Suppose that the interest rate $i = 7.5\%$ (cell B3 of a worksheet) and the period length $n = 1$ (B2) remain constant. We want to know how much investment capital $C$ is needed to achieve a return of $I = $15,000. Assume that our initial capital estimate is $C = $100,000 (B1).

To calculate the return:

1) Enter the return formula ($=B1 \times B2 \times B3$) into B4 and select the cell with the mouse.
2) Select **Tools > Goal Seek** from the Menu bar to open the Goal Seek dialog.
3) B4 should already be entered in the **Formula cell** field. However, if you want to select a different cell, use the associated **Shrink / Expand** button to minimize the dialog while you select the required cell.
4) Click on the **Variable cell** field, then type a reference to cell B1 or select it with the mouse to make the capital the variable in the current Goal Seek.
5) Enter the desired formula result in the **Target value** field. In this example, the value is 15000. Figure 25 shows the cells and dialog fields at this point.

![Figure 24: Goal Seek dialog](image)

![Figure 25: Example setup for goal seek](image)
6) Click OK. A dialog appears informing you that the goal seek was successful (Figure 26).

![Figure 26: Goal seek result dialog]

7) Click Yes to enter the goal value into the variable cell. The result is shown in Figure 27, indicating that a capital requirement of $200,000 is needed to achieve a $15,000 return.

![Figure 27: Result of goal seek in worksheet]

**Note**

Not every goal seek problem succeeds in returning a good result. It depends on the formula used, goal value, and initial value. The goal seek algorithm iterates internally several times converging to the goal.

### Using the Solver

The Solver amounts to a more elaborate form of goal seek, which allows you to solve mathematical programming or optimization problems. A mathematical programming problem is concerned with minimizing or maximizing a function subject to a set of constraints. Such problems arise in many scientific, engineering, business, and other disciplines. A full discussion of mathematical programming is beyond the scope of this guide and the interested reader is referred to the relevant Wikipedia page at [https://en.wikipedia.org/wiki/Mathematical_optimization](https://en.wikipedia.org/wiki/Mathematical_optimization), which provides high level information and references to more detailed materials.

Currently Calc offers the following selection of solver engines:

- DEPS (Differential Evolution & Particle Swarm Optimization) Evolutionary Algorithm.
- SCO (Social Cognitive Optimization) Evolutionary Algorithm.
- LibreOffice CoinMP Linear Solver.
- LibreOffice Linear Solver.
- LibreOffice Swarm Non-Linear Solver (experimental).

**Caution**

As the LibreOffice Swarm Non-Linear Solver is an experimental tool, it may not be supported in future versions of Calc, and we recommend that you do not use it unless you are familiar with non-linear programming concepts.
The DEPS and SCO Evolutionary Algorithms are intended for solving non-linear problems and are only available if you have selected **Tools > Options > LibreOffice > Advanced > Use a Java runtime environment**. The DEPS Evolutionary Algorithm is the initial default if it is available, while LibreOffice CoinMP Linear Solver is the initial default otherwise.

The available options provide flexibility to choose the most suitable algorithm for a given problem, which may be linear or non-linear, and a given performance requirement.

In order to use the Solver to solve a mathematical programming problem, you must formulate the problem as follows:

- **Decision variables** – a set of $n$ non-negative variables $x_1, \ldots, x_n$. Decision variables may be real numbers, but generally tend to be integers in many real world problems.
- **Constraints** – a set of linear equalities or inequalities involving the decision variables.
- **Objective function** – a linear expression involving the decision variables.

The goal is usually to find values of the decision variables that satisfy the constraints and maximize or minimize the result of the objective function.

**Solver dialog**

After setting up the data for the problem in your Calc spreadsheet, select **Tools > Solver** from the Menu bar to open the Solver dialog (Figure 28).

![Solver dialog](image)

*Figure 28: Solver dialog*
Note

Depending on the configuration of your computer, a message may be displayed the first time that you select Tools > Solver after starting Calc. The nature of this message will change dependent on the existence of a Java runtime environment (JRE) on your system. If no JRE is detected, the message will simply be a warning to that effect. In the case where a JRE is detected but the Tools > Options > LibreOffice > Advanced > Use a Java runtime environment option is disabled, then the message will include a button to enable that option.

Target cell
Type a cell reference to the objective function or select it with the mouse.

Optimize result to
Select Maximum to find the maximum result for the objective function, Minimum to find the minimum result, or Value of to set it to a specific value. If you select Value of, enter the required value or a reference to the cell containing that value.

By changing cells
Enter the locations of any cells that define your decision variables.

Limiting Conditions
Enter your constraints in the fields in this area:
- Cell reference – enter a cell reference to a decision variable.
- Operator – defines a parameter for a constraint. Available options include <= (less than or equal to), = (equal to), => (greater than or equal to), Integer (values without decimals), and Binary (only 0 or 1).
- Value – enter a value or a cell reference to a constraint formula.
- Remove button – deletes the currently-defined constraint.

Tip
Remember that for any of these options, you can minimize the Solver dialog using the associated Shrink / Expand buttons if you need to select cells with the mouse.

Once you have finished setting up the Solver, click the Solve button to begin the process of adjusting values and calculating results. Depending on the complexity of the task, this may take some time. On successful completion, Calc presents a Solving Result dialog (Figure 29). This dialog includes buttons to save (Keep Result) or discard (Restore Previous) your results.

The Solver dialog also has an Options button, which opens the Options dialog shown in Figure 30.
Solver options

Solver engine
With the standard LibreOffice 6.4 download, and an enabled Java runtime environment, the Solver engine drop-down list provides five options:

• DEPS Evolutionary Algorithm
• SCO Evolutionary Algorithm
• LibreOffice CoinMP Linear Solver
• LibreOffice Linear Solver
• LibreOffice Swarm Non-Linear Solver (experimental)

Settings
This area enables the user to adjust the detailed processing parameters of the selected solver engine, and the options available vary between engines.

Solver example
Suppose that you have $10,000 that you want to invest in two mutual funds for one year. Fund X is a low risk fund with an 8% interest rate and Fund Y is a higher risk fund with a 12% interest rate. How much money should be invested in each fund to earn a total interest of $1,000?

To find the answer using the Solver:

1) Enter the following labels and data into a worksheet:
   • Row labels: Fund X, Fund Y, and Total in cells A2, A3, and A4.
   • Column labels: Interest earned, Amount invested, Interest rate, and Time period in cells B1 thru E1.
   • Interest rates: 8% and 12% in cells D2 and D3.
   • Time period: 1 in cells E2 and E3.
   • Total amount invested: $10000 in cell C4.
   • Enter an arbitrary value ($0 or leave blank) in cell C2 as the amount invested in Fund X.

2) Enter the following formulas:
   • In cell C3, enter the formula =C4–C2 (total amount – amount invested in Fund X) as the
amount invested in Fund Y.

- In cells B2 and B3, enter the formulas =C2*D2*E2 (B2) and =C3*D3*E3 (B3).
- In cell B4, enter the formula =B2+B3 as the total interest earned. Figure 31 shows the worksheet at this point.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>Interest earned</td>
<td>Amount invested</td>
<td>Interest rate</td>
<td>Time period</td>
</tr>
<tr>
<td>2</td>
<td>Fund X</td>
<td>$0</td>
<td>$0</td>
<td>8%</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Fund Y</td>
<td>$1,200</td>
<td>$10,000</td>
<td>12%</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Total</td>
<td>$1,200</td>
<td>$10,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 31: Solver example setup

3) Select Tools > Solver from the Menu bar to open the Solver dialog (Figure 28).
4) Using the Target cell field, select the cell that contains the target value. In this example, it is B4, which contains the total interest value.
5) Select Value of and enter 1000 in the field next to it. In this example, the target cell value is 1000 because your target is a total interest earned of $1,000.
6) Using the By changing cells field, select cell C2 in the sheet. In this example, you need to find the amount invested in Fund X (cell C2).
7) Enter the following limiting conditions for the variables by using the Cell reference, Operator, and Value fields:
   - C2 <= C4 – the amount invested in Fund X cannot exceed the total amount available.
   - C2 >= 0 – the amount invested in Fund X cannot be negative.
   - C2 is an Integer – specified for convenience.
8) Click Solve. The result is shown in Figure 32.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>Interest earned</td>
<td>Amount invested</td>
<td>Interest rate</td>
<td>Time period</td>
</tr>
<tr>
<td>2</td>
<td>Fund X</td>
<td>$400</td>
<td>$5,000</td>
<td>8%</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Fund Y</td>
<td>$600</td>
<td>$5,000</td>
<td>12%</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Total</td>
<td>$1,000</td>
<td>$10,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 32: Solver example result

Using Statistics tools

Under Data > Statistics in the Menu bar, Calc features several tools for quick and easy statistical analysis of your data. These tools include:

- Sampling
- Descriptive Statistics
- Analysis of Variance (ANOVA)
- Correlation
- Covariance
- Exponential Smoothing
- Moving Average
- Regression
• Paired t-test
• F-test
• z-test
• Test of Independence (Chi-square)
• Fourier Analysis

**Sampling tool**

The Sampling tool creates a target table with data sampled from a source table. The sampling tool can pick samples randomly or on a periodic basis. Sampling is done row-wise, with whole rows of the source table copied into rows of the target table. To use this tool, select **Data > Statistics > Sampling** from the Menu bar to access the Sampling dialog (Figure 33).

![Sampling dialog](image)

**Input range**

Specifies the cell range containing the source table.

**Results to**

Specifies the top left cell of the target table. When you run the tool, it will fill out the rest of the target table starting from this cell.

**Random**

Enables random sampling mode when selected.

**Sample size**

Defines the number of lines to be sampled from the source table during random sampling. Only available if the **Random** option is selected. If **With replacement** is deselected, the maximum value that can be entered in this field is limited to the number of rows in the source table.

**With replacement**

If this option is selected, a sample drawn from the source table is effectively returned and so is eligible for re-sampling later. In this case, the sample size can be larger than the number of
rows in the source table. If the option is deselected, a sample drawn from the source table is not eligible for re-sampling later. In this case, the sample size is limited to the number of rows in the source table. This option is automatically deselected for periodic sampling. It is not possible to have both With replacement and Keep order options selected simultaneously.

Keep order
If this option is selected, samples are drawn from the source table in order of the data in the source table. If deselected, samples are drawn in random order from the source table. This option is automatically selected for periodic sampling. It is not possible to have both With replacement and Keep order options selected simultaneously.

Periodic
Enables periodic sampling mode when selected.

Period
Defines the number of lines to skip between samples during periodic sampling. For example, a value of 2 will cause alternate lines to be sampled from the source table, starting with the second line. Only available if the Periodic option is selected. The maximum value that can be entered in this field is limited to the number of rows in the source table.

Tip
Use the Shrink / Expand buttons next to the Input range and Results to fields if you need to shrink the dialog while selecting cells with the mouse.

Figure 34 shows the source table (below the Source Data heading) and the corresponding target table (under the Target Data heading), sampled using the settings shown in Figure 33.

![Figure 34: Example data for the Sampling tool](image)

Descriptive Statistics tool
Given a set of data, the Descriptive Statistics tool creates a tabular report of a data set's primary statistical properties, such as information about its central tendency and variability. Select Data > Statistics > Descriptive Statistics in the Menu bar to access the Descriptive Statistics dialog (Figure 35).
Input range
Specifies the cell range containing the source data.

Results to
Specifies the top left cell of the results area. When you run the tool, it will fill out the rest of the report table starting at this cell.

Columns / Rows
Specifies whether the data to be analyzed is organized in columns or rows.

Tip
Use the Shrink / Expand buttons next to the Input range and Results to fields if you need to shrink the dialog while selecting cells with the mouse.

Figure 36 shows a small data set comprising student examination results in three subjects.

![Input data for descriptive statistics analysis](image)

Figure 37 shows the statistics report generated for this input data using the settings shown in Figure 35.
The Analysis of Variance (ANOVA) tool compares the means of two or more groups in a sample. Select **Data > Statistics > Analysis of Variance (ANOVA)** in the Menu bar to access the Analysis of Variance (ANOVA) dialog (Figure 38).

**Tip**


### Analysis of Variance (ANOVA) tool

<table>
<thead>
<tr>
<th></th>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>41.909091</td>
<td>59.7</td>
<td>44.7</td>
</tr>
<tr>
<td>Standard Error</td>
<td>3.561038</td>
<td>5.358379</td>
<td>4.780065</td>
</tr>
<tr>
<td>Mode</td>
<td>47</td>
<td>49</td>
<td>60</td>
</tr>
<tr>
<td>Median</td>
<td>40</td>
<td>64.5</td>
<td>43.5</td>
</tr>
<tr>
<td>First Quartile</td>
<td>32.5</td>
<td>49</td>
<td>40.5</td>
</tr>
<tr>
<td>Third Quartile</td>
<td>51.5</td>
<td>67.75</td>
<td>57.75</td>
</tr>
<tr>
<td>Variance</td>
<td>139.490909</td>
<td>287.122222</td>
<td>227.344444</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>11.810627</td>
<td>16.944681</td>
<td>15.077946</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-1.462168</td>
<td>-0.041500</td>
<td>1.418053</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.015241</td>
<td>-0.222643</td>
<td>-0.976680</td>
</tr>
<tr>
<td>Range</td>
<td>31</td>
<td>51</td>
<td>50</td>
</tr>
<tr>
<td>Minimum</td>
<td>26</td>
<td>33</td>
<td>12</td>
</tr>
<tr>
<td>Maximum</td>
<td>57</td>
<td>84</td>
<td>62</td>
</tr>
<tr>
<td>Sum</td>
<td>461</td>
<td>507</td>
<td>447</td>
</tr>
<tr>
<td>Count</td>
<td>11</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

*Figure 37: Results from Descriptive Statistics tool*

*Figure 38: Analysis of Variance (ANOVA) dialog*
Input range
Specifies the cell range containing the source data.

Results to
Specifies the top left cell of the results area. When you run the tool, it will fill out the analysis of variance report table starting at this cell.

Single / Two factor
Determines whether the analysis is for single factor or two factor ANOVA.

Columns / Rows
Specifies whether the data to be analyzed is organized in columns or rows. Only available if Single factor is selected.

Alpha
In this field, enter a significance level in the range 0.01 to 0.99. The default is 0.05.

Rows per sample
Defines how many rows a sample has. This option is always set to 1 in this version of Calc.

To illustrate how to use this tool, we use the input data set from Figure 36. Figure 39 shows the analysis of variance results generated for this data using the settings shown in Figure 38.

![Figure 39: Results from Analysis of Variance (ANOVA) tool](image)

Tip

Correlation tool
The Correlation tool calculates the correlation of two sets of numeric data and generates the resulting correlation coefficient. This coefficient is a value between -1 and +1 that indicates how strongly two variables are related to each other. A correlation coefficient of +1 indicates a perfect positive correlation (the data sets match) and a coefficient of -1 indicates a perfect negative correlation (the data sets are inverse to each other). Select Data > Statistics > Correlation in the Menu bar to access the Correlation dialog (Figure 40).

Input range
Specifies the cell range containing the source data.

Results to
Specifies the top left cell of the results area. When you run the tool, it will fill out the correlation coefficient table starting at this cell.
Columns / Rows
Specifies whether the data to be analyzed is organized in columns or rows.

To illustrate how to use this tool, we again use the data set from Figure 36. Figure 41 shows the six correlation coefficients generated for this input data using the settings shown in Figure 40.

For more information on statistical correlation, refer to the corresponding Wikipedia article at https://en.wikipedia.org/wiki/Correlation_and_dependence.

Covariance tool
The Covariance tool measures how much two sets of numeric data vary together. Select Data > Statistics > Covariance in the Menu bar to access the Covariance dialog (Figure 42).

Input range
Specifies the cell range containing the source data.
Results to
Specifies the top left cell of the results area. When you run the tool, it will fill out the covariance table starting at this cell.

Columns / Rows
Specifies whether the data to be analyzed is organized in columns or rows.

To illustrate how to use this tool, we again use the data set from Figure 36. Figure 43 shows the six covariance values generated for this input data using the settings shown in Figure 42.

<table>
<thead>
<tr>
<th>Covariances</th>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column 1</td>
<td>126.809917</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Column 2</td>
<td>-61444444</td>
<td>258.41</td>
<td></td>
</tr>
<tr>
<td>Column 3</td>
<td>-32</td>
<td>53.11</td>
<td>204.61</td>
</tr>
</tbody>
</table>

*Figure 43: Covariance results*

**Tip**

**Exponential Smoothing tool**
The Exponential Smoothing tool filters a data set to produce smoothed results. It is used in domains such as stock market analysis and in sampled measurements. Select **Data > Statistics > Exponential Smoothing** in the Menu bar to access the Exponential Smoothing dialog (Figure 44).

<table>
<thead>
<tr>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input range:</td>
</tr>
<tr>
<td>Results to:</td>
</tr>
</tbody>
</table>

**Grouped by**
- Columns
- Rows

**Parameters**
- Smoothing factor: 0.50

*Figure 44: Exponential Smoothing dialog*

**Input range**
Specifies the cell range containing the source data.

**Results to**
Specifies the top left cell of the results area. When you run the tool, it will generate smoothed results starting at this cell.

**Columns / Rows**
Specifies whether the data to be analyzed is organized in columns or rows.
Smoothing factor
Enter a value here between 0 and 1 (default is 0.2) that represents the damping factor alpha in the smoothing equation.

To illustrate how to use this tool, we use the data set shown in Figure 45. The table has two time series representing impulse functions at times t=0 and t=2.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*Figure 45: Input data set for exponential smoothing example*

Figure 46 shows the smoothed results for this input data using the settings shown in Figure 44.

<table>
<thead>
<tr>
<th></th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Column 1</td>
<td>Column 2</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>0.25</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>0.125</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>0.0625</td>
<td>0.125</td>
<td></td>
</tr>
<tr>
<td>0.03125</td>
<td>0.0625</td>
<td></td>
</tr>
<tr>
<td>0.015625</td>
<td>0.03125</td>
<td></td>
</tr>
<tr>
<td>0.0078125</td>
<td>0.015625</td>
<td></td>
</tr>
<tr>
<td>0.00390625</td>
<td>0.0078125</td>
<td></td>
</tr>
<tr>
<td>0.001953125</td>
<td>0.00390625</td>
<td></td>
</tr>
<tr>
<td>0.0009765625</td>
<td>0.001953125</td>
<td></td>
</tr>
<tr>
<td>0.00048828125</td>
<td>0.0009765625</td>
<td></td>
</tr>
<tr>
<td>0.000244140625</td>
<td>0.00048828125</td>
<td></td>
</tr>
</tbody>
</table>

*Figure 46: Results from Exponential Smoothing tool*

**Tip**

Moving Average tool
The Moving Average tool calculates the moving average of a time series data set. Select Data > Statistics > Moving Average in the Menu bar to access the Moving Average dialog (Figure 47).
Input range
Specifies the cell range containing the source data.

Results to
Specifies the top left cell of the results area. When you run the tool, it will generate the moving average results starting at this cell.

Trim input range to actual data content
Specifies whether to allow trimming of the input range to the actual data content before computing the moving average. Enabled by default to provide better performance.

Columns / Rows
Specifies whether the data to be analyzed is organized in columns or rows.

Interval
Specifies the number of samples used in the moving average calculation.

To illustrate how to use this tool, we again use the data set from Figure 45. Figure 48 shows the moving averages calculated for this input data using the settings shown in Figure 47.
Tip

For more information on the moving average, refer to the corresponding Wikipedia article at https://en.wikipedia.org/wiki/Moving_average.

Regression tool

The Regression tool analyzes the relationship in a data set between one or more independent variables and a dependent variable. Select Data > Statistics > Regression in the Menu bar to access the Regression dialog (Figure 49).

**Independent variable(s) (X) range**
- Specifies the cell range containing the independent variables in the source data.

**Dependent variable (Y) range**
- Specifies the cell range containing the dependent variable in the source data.

**Both X and Y ranges have labels**
- Specifies whether the ranges above include data labels.

**Results to**
- Specifies the top left cell of the results area. When you run the tool, it will generate the regression analysis table starting at this cell.

**Columns / Rows**
- Specifies whether the data to be analyzed is organized in columns or rows.

**Linear Regression**
- Select this option to use linear regression. Linear regression finds a straight line in the form of $y = (a \cdot x) + b$ that best fits the data, where $a$ is the slope and $b$ is the intercept.

**Logarithmic Regression**
- Select this option to use logarithmic regression. Logarithmic regression finds a logarithmic curve in the form of $y = (a \cdot \ln(x)) + b$ that best fits the data, where $a$ is the slope, $b$ is the intercept and $\ln(x)$ is the natural logarithm of $x$.

**Power Regression**
- Select this option to use power regression. Power regression finds a power curve in the form of $y = (a \cdot x)^b$ that best fits the data, where $a$ is the coefficient and $b$ is the exponent.

**Confidence level**
- Specifies the confidence level, which is a value between 0 and 1. The default value is 0.95.

**Calculate residuals**
- Specifies whether to calculate residuals.

**Force intercept to be zero**
- Specifies whether to force the regression intercept to be 0.
Tip

Use the **Shrink / Expand** buttons next to the **Independent variable(s) (X) range**, **Dependent variable (Y) range**, and **Results to** fields if you need to shrink the dialog while selecting cells with the mouse.

To illustrate how to use this tool, we use the data set shown in Figure 50. This table contains measurements taken at 1 second intervals.

![Figure 50: Input data set for regression analysis](image)

40 | Regression tool
Figure 51 shows the regression outputs calculated for this input data using the settings shown in Figure 49.

### Tip

<table>
<thead>
<tr>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression Model</td>
<td>Linear</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>LINEST raw output</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-0.219394</td>
<td>4.886667</td>
<td>0.205790</td>
<td>1.276946</td>
<td>0.124390</td>
<td>1.899257</td>
<td>1.136489</td>
</tr>
<tr>
<td>0.205790</td>
<td>1.276946</td>
<td>0.124390</td>
<td>1.899257</td>
<td>1.136489</td>
<td>0</td>
<td>3.971030</td>
</tr>
<tr>
<td>1.136489</td>
<td>0</td>
<td>3.971030</td>
<td>27.952970</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression Statistics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>R^2</strong></td>
<td>0.124390</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard Error</td>
<td>1.8689257</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count of x-variables</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted R^2</td>
<td>0.014939</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analysis of Variance (ANOVA)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>df</td>
<td>SS</td>
<td>MS</td>
<td>F</td>
<td>Significance F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression</td>
<td>1</td>
<td>3.971030</td>
<td>3.971030</td>
<td>1.136489</td>
<td>0.317509</td>
<td></td>
</tr>
<tr>
<td>Residual</td>
<td>8</td>
<td>27.952970</td>
<td>3.494121</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>31.924</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Confidence level</td>
<td>0.95</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coefficients</td>
<td>4.886667</td>
<td>1.276946</td>
<td>3.811178</td>
<td>0.005154</td>
<td>1.922025</td>
<td>7.811308</td>
</tr>
<tr>
<td>Time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coefficients</td>
<td>-0.219394</td>
<td>0.205790</td>
<td>-1.066082</td>
<td>0.317509</td>
<td>-0.693966</td>
<td>0.255178</td>
</tr>
</tbody>
</table>

**Figure 51: Linear regression outputs**

### Paired T-test tool
The Paired T-test tool compares the population means of two related sample sets and determines the difference between the two. Select **Data > Statistics > Paired t-test** in the Menu bar to access the Paired t-test dialog (Figure 52).
Variable 1 range
Specifications the cell range containing the first set of input data.

Variable 2 range
Specifications the cell range containing the second set of input data.

Results to
Specifications the top left cell of the results area. When you run the tool, it will generate the paired t-test table starting at this cell.

Columns / Rows
Specifications whether the data to be analyzed is organized in columns or rows.

To provide an example of using this tool, we make use of the input data set shown in Figure 53. The data sets in columns A and B represent two sets of paired values referred to as Variable 1 and Variable 2.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>28</td>
<td>19</td>
</tr>
<tr>
<td>2</td>
<td>26</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>31</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>23</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>34</td>
</tr>
<tr>
<td>6</td>
<td>27</td>
<td>31</td>
</tr>
<tr>
<td>7</td>
<td>28</td>
<td>31</td>
</tr>
<tr>
<td>8</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>9</td>
<td>4</td>
<td>24</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>23</td>
</tr>
<tr>
<td>11</td>
<td>2</td>
<td>19</td>
</tr>
<tr>
<td>12</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>13</td>
<td>9</td>
<td>33</td>
</tr>
</tbody>
</table>

Figure 54: Paired t-test results calculated for this input data using the settings shown in Figure 52.
Tip

For more information on paired t-tests, refer to the corresponding Wikipedia article at [https://en.wikipedia.org/wiki/Student%27s_t-test](https://en.wikipedia.org/wiki/Student%27s_t-test).

<table>
<thead>
<tr>
<th>( D )</th>
<th>( E )</th>
<th>( F )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Paired t-test</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alpha</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Hypothesised Mean Difference</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Variable 1</strong></td>
<td><strong>Variable 2</strong></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>16.923077</td>
<td>20.461538</td>
</tr>
<tr>
<td>Variance</td>
<td>125.076923</td>
<td>94.435897</td>
</tr>
<tr>
<td>Observations</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>-0.061754</td>
<td></td>
</tr>
<tr>
<td>Observed Mean Difference</td>
<td>-3.538462</td>
<td></td>
</tr>
<tr>
<td>Variance of the Differences</td>
<td>232.955897</td>
<td></td>
</tr>
<tr>
<td>( df )</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>( t ) Stat</td>
<td>-0.835926</td>
<td></td>
</tr>
<tr>
<td>( P (T \leq t) ) one-tail</td>
<td>0.209765</td>
<td></td>
</tr>
<tr>
<td>( t ) Critical one-tail</td>
<td>1.782288</td>
<td></td>
</tr>
<tr>
<td>( P (T \leq t) ) two-tail</td>
<td>0.419530</td>
<td></td>
</tr>
<tr>
<td>( t ) Critical two-tail</td>
<td>2.178813</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 54: Results from Paired T-test tool**

**F-test tool**

The F-test tool calculates the F-Test of two data samples. The tool is used to test the hypothesis that the variance of two populations are equal. Click **Data > Statistics > F-test** in the Menu bar to access the F-test dialog shown in Figure 55 and define the required inputs to the tool.

![F-test dialog](image)

**Figure 55: F-test dialog**

**Variable 1 range**

Specifies the cell range containing the first set of input data.

**Variable 2 range**

Specifies the cell range containing the second set of input data.
Results to
Specifies the top left cell of the results area. When you run the tool, it will generate the F-test table starting at this cell.

Columns / Rows
Specifies whether the data to be analyzed is organized in columns or rows.

Tip
Use the Shrink / Expand buttons next to the Variable 1 range, Variable 2 range, and Results to fields if you need to shrink the dialog while selecting cells with the mouse.

To illustrate how to use this tool, we again use the data set from Figure 53. In this case, the data in columns A and B represent two independent sample sets, referred to as Variable 1 and Variable 2. Figure 56 shows the F-test results calculated for this input data using the settings shown in Figure 55.

<table>
<thead>
<tr>
<th></th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-test</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alpha</td>
<td>0.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Variable 1</td>
<td>Variable 2</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>16.923077</td>
<td>20.461538</td>
<td></td>
</tr>
<tr>
<td>Variance</td>
<td>125.076923</td>
<td>94.435807</td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>13</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>df</td>
<td>12</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>1.324464</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P (F&lt;=f right-tail)</td>
<td>0.317061</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F Critical right-tail</td>
<td>2.686637</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P (F&lt;=f left-tail)</td>
<td>0.682939</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F Critical left-tail</td>
<td>0.372213</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P two-tail</td>
<td>0.634123</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F Critical two-tail</td>
<td>0.305131</td>
<td>3.277277</td>
<td></td>
</tr>
</tbody>
</table>

Figure 56: Results from F-test tool

Tip
For more information on F-tests, refer to the corresponding Wikipedia article at https://en.wikipedia.org/wiki/F-test.

Z-test tool
The Z-test tool calculates the Z-test of two data samples. The tool performs a two sample Z-test to test the null hypothesis that there is no difference between the means of the two data sets. Click Data > Statistics > Z-test in the Menu bar to access the z-test dialog shown in Figure 57 and define the required inputs to the tool.

Variable 1 range
Specifies the cell range containing the first set of input data.

Variable 2 range
Specifies the cell range containing the second set of input data.

Results to
Specifies the top left cell of the results area. When you run the tool, it will generate the Z-test table starting at this cell.

Columns / Rows
Specifies whether the data to be analyzed is organized in columns or rows.

44 | Z-test tool
Tip

Use the **Shrink / Expand** buttons next to the **Variable 1 range**, **Variable 2 range**, and **Results to** fields if you need to shrink the dialog while selecting cells with the mouse.

Figure 57: z-test dialog

To provide an example of using this tool, we again make use of the input data set shown in Figure 53. In this case the data in columns A and B represent two data sets, referred to as **Variable 1** and **Variable 2**. Figure 58 shows the Z-test results calculated for this input data using the settings shown in Figure 57.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>D</strong></td>
<td><strong>E</strong></td>
<td><strong>F</strong></td>
</tr>
<tr>
<td><strong>z-test</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alpha</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Hypothesised Mean Difference</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Variable 1</strong></td>
<td><strong>Variable 2</strong></td>
<td></td>
</tr>
<tr>
<td>Known Variance</td>
<td>0.000000</td>
<td>0.000000</td>
</tr>
<tr>
<td>Mean</td>
<td>16.923077</td>
<td>20.451538</td>
</tr>
<tr>
<td>Observations</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Observed Mean Difference</td>
<td>-3.538462</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>#DIV/0!</td>
<td>#DIV/0!</td>
</tr>
<tr>
<td>P (Z&lt;=z) one-tail</td>
<td>#DIV/0!</td>
<td>#DIV/0!</td>
</tr>
<tr>
<td>z Critical one-tail</td>
<td>1.644854</td>
<td>#DIV/0!</td>
</tr>
<tr>
<td>P (Z&lt;=z) two-tail</td>
<td>#DIV/0!</td>
<td>#DIV/0!</td>
</tr>
<tr>
<td>z Critical two-tail</td>
<td>1.959964</td>
<td></td>
</tr>
</tbody>
</table>

Figure 58: Results from Z-test tool

Tip


**Test of Independence (Chi-Square) tool**

The Test of Independence (Chi-Square) tool calculates the chi-square test of a data sample, which determines how well a set of measured values fit a corresponding set of expected values. Select **Data > Statistics > Chi-square Test** in the Menu bar to access the Test of Independence (Chi-Square) dialog (Figure 59).
Input range
Specifies the cell range containing the source data.

Results to
Specifies the top left cell of the results area. When you run the tool, it will generate the Chi-square table starting at this cell.

Columns / Rows
Specifies whether the data to be analyzed is organized in columns or rows.

To provide an example of using this tool, we again make use of the input data set shown in Figure 53. In this case the data in column A is the observed data while the data in column B are the corresponding expected values. Figure 60 shows the chi-square results calculated for this input data using the settings shown in Figure 59.

Fourier Analysis tool
The Fourier Analysis tool performs the Fourier analysis of a data set by computing the Discrete Fourier Transform (DFT) of an input array of complex numbers, using Fast Fourier Transform (FFT) algorithms. Select Data > Statistics > Fourier Analysis in the Menu bar to access the Fourier Analysis dialog (Figure 61).

Tip
For more information on chi-square tests, refer to the corresponding Wikipedia article at https://en.wikipedia.org/wiki/Chi-squared_test.
Input range
Specifies the cell range containing the source data. A 2 x N or N x 2 range representing an array of complex numbers to be transformed, where N is the length of the array. The array contains the real and imaginary parts of the data.

Results to
Specifies the top left cell of the results area. When you run the tool, it will generate the Fourier transform table starting at this cell.

Input range has label
Specifies whether the first row or column of the input array is a label and not part of the data to be analyzed.

Columns / Rows
Specifies whether the data to be analyzed is organized in columns or rows.

Inverse
If ticked, the tool calculates an inverse Discrete Fourier Transform.

Output in polar form
If ticked, the tool outputs the results in polar coordinates (that is, magnitude and phase).

Minimum magnitude for polar form output
This option is only relevant when you select to output results in polar form. All frequency components with magnitude less than the specified value in decibels will be suppressed with a zero magnitude-phase entry. This is useful when looking at the magnitude-phase spectrum of a signal because there is always some tiny rounding error when performing FFT algorithms, which results in incorrect non-zero phase for non-existent frequencies. By providing a suitable value to this parameter, these non-existent frequency components can be suppressed.

To provide an example of using this tool, we make use of the input data set shown in columns B (real values) and C (imaginary values) of the spreadsheet shown in Figure 62. The data shown in
columns E (real values) and F (imaginary values) of the spreadsheet are the Fourier transform results calculated by the tool for this input data, using the settings shown in Figure 61.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Source Array</td>
<td>Array</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Real</td>
<td>Imaginary</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.3925555412</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1.208437017</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0.851477677</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1.879546519</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1.779465061</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>1.518006002</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>1.046946661</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>0.831100818</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>1.230062285</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>0.133409796</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>1.30471656</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>0.386478762</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>-0.703398288</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>-0.8911531</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>-1.2404551</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>-0.51355315</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>-0.613679106</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>0.326072595</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>0.031629781</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>0.522987259</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>0.436798031</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>0.846212627</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>0.91360109</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>1.256620753</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>1.65565048</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>1.35826362</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>1.46721209</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>0.66120487</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>0.70153432</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>0.658603682</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>0.23752245</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>-0.49991136</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>-0.53168075</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>-0.79684084</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>-0.62141730</td>
<td>0</td>
<td>0</td>
<td></td>
<td>4.77453E-15</td>
<td>17.17755787</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 62: Fourier analysis tool - example input data and results**

Note

For those with a technical interest in the algorithms used by the Fourier Analysis tool, a radix-2 decimation-in-time FFT is used when the length of the input sequence is an even power of 2, while Bluestein’s FFT algorithm is used when the length of the input sequence is not an even power of 2.
Tip

For more information on Fourier analysis, refer to the corresponding Wikipedia article at https://en.wikipedia.org/wiki/Fourier_analysis.