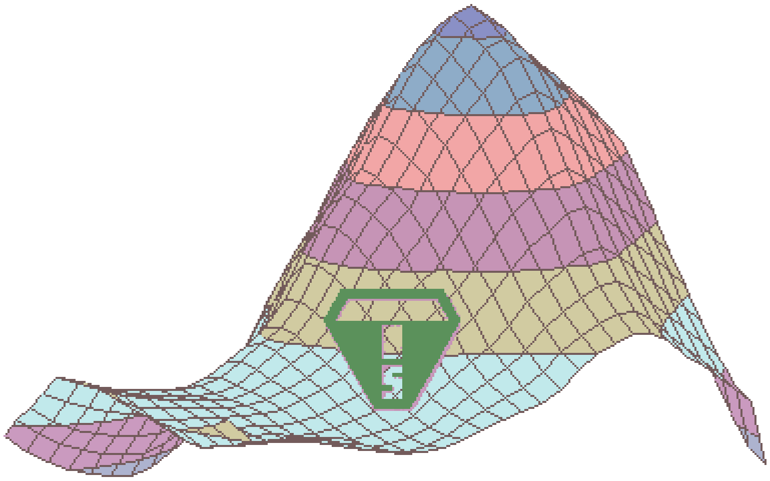
TriLookup™ and TriLookupLite™ Version 3.0 User's Guide



For latest updates see www.trimill.com/TriLookup

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General Information

TriLookup and TriLookupLite Editions

Starting in version 3.0, Trimill introduced **TriLookupLite**, as a Freeware edition of TriLookup. The differences between TriLookup and TriLookupLite are outlined in the table below:

Description	TriLolokup	TriLookupLite
Type of license	Shareware	Freeware
Registration	Required after a 30-day evaluation period	Not required
Version compatible with 64 bit Excel for Windows	Available by request to registered TriLookup users only	Available for download
Version compatible with Mac Excel (32 bit and 64 bit)	Available by request to registered TriLookup users only	Available for download
Limitations on the type of interpolation (parameters *Interpolate*, *X_Interpolate*, *Y_Interpolate* and Z*_Interpolate*)	No limitations (valid values: -20 to 7)	Limited to: *No interpolation* (exact match, exact match or lower, exact match or higher, closest value) and *Linear Interpolation* (valid values: 0 to 4)
Limitations on the maximum polynomial order (parameter *Max_order* in TVPOLYDATA and THPOLYDATA functions)	No limitations (valid values: 1 to 20)	Limited to 6 (valid values: 1 to 6)

Apart from the differences outlined above, the eleven TriLookup worksheet functions work exactly the same way on both TriLookup and TriLookupLite.

Note:

You can have either TriLookup or TriLookupLite installed on your computer at one time. Installing TriLookup or TriLookupLite will overwrite any previous installation of TriLookup or TriLookupLite.

Implementations of TriLookup and TriLookupLite

TriLookup edition is available in three different implementations:

- **TriLookup 32 Win**, which works on **32 bit Excel** versions 97 - 2016 for Windows (any version of Windows, both 32 bit and 64 bit);
- **TriLookup 64 Win**, which works on **64 bit Excel** versions 2007 - 2016 for Windows (any version of 64 bit Windows);
- **TriLookup Mac**, which works on 32 bit and 64 bit Excel versions 98 or through 2016 for Macintosh (with the exception of Mac Excel version 2008, which doesn't support VBA).

TriLookupLite edition is also available comes in three different implementations:

- **TriLookupLite 32 Win**, which works on **32 bit Excel** versions 97 - 2016 for Windows (any version of Windows, both 32 bit and 64 bit);
- **TriLookupLite 64 Win**, which works on **64 bit Excel** versions 2007 - 2016 for Windows (any version of 64 bit Windows);
- **TriLookupLite Mac**, which works on **Mac Excel** versions 98 or through 2016 for Macintosh (with the exception of Mac Excel version 2008, which doesn't support VBA).

The eleven TriLookup worksheet functions work exactly the same way on both Windows and Macintosh, on all supported versions of Excel.

The differences between **32 Win**, **64 Win** and **Mac** implementations of **TriLookup** and **TriLookupLite** are shown in the table below:

Implementation	**32 Win**	**64 Win**	**Mac**
Installing	Automatic, via Windows setup program	Automatic, via Windows setup program	Manual, unzip files and add through Excel Add-ins dialog
Online help file	Includes TriLookup.hlp	Includes TriLookup.hlp	Not included
TriLookup functions in the **Paste Function** dialog are listed in	custom **TriLookup** category	built in **Lookup & Reference** category	built in **Lookup & Reference** category
Help messages for function parameters in the **Formula Palette** dialog	Yes	No	No

Revision History

Version 3.0 (03-Sep-2016)

- Introduced **TriLookupLite** as a freeware edition of TriLookup.
- Rewritten portions of the TriLookup user's manual and Help File.
- Updated Website support on www.trimill.com/TriLookup

Version 2.4 (31-Aug-2016)

- Fixed the bug that prevented launching TriLookup examples from the TriLookup program group in the Start menu.
- Added "4D Lookup" example sheet to the Practical Examples worksheet (PractcalExamples.xls).

Version 2.3 (18-Oct-2015)

- From this release forward, TriLookup will also install automatically on **Excel for Windows** versions 2013 and 2016.
- From this release forward, a version of TriLookup is also available for Excel 64 bit. Due to restrictions imposed by 64 bit Excel, this version differs from the regular TriLookup in a few details, as follows:
    - All dialogs and menu entries removed.
    - The TriLookup functions appear in the "Lookup & Reference" category of the Insert Function dialog (not a separate TriLookup category like in the 32 version).
    - This version does not allow for 30-day evaluation and does not require the registration code to be activated. For that reason it is available only to registered TriLookup users by email request to info@trimill.com at no additional cost (our policy doesn't include making money by selling you the same software over and over again).
    - This version also works on Excel 2011 for Macintosh, which doesn't support regular TriLookup. Unfortunately, no version of TriLookup works on Mac Excel 2008 because, due to strange wisdom that has been guiding Microsoft, that one doesn't support VBA.
- New feature was added in TVPOLYDATA and THPOLYDATA functions. They now have one more optional parameter at the end, called **QR_mode**. When QR_mode is set to True (default is False), TriLookup will solve the least squares equation using Householder QR decomposition method (for more details on QR decomposition method see https://en.wikipedia.org/wiki/QR_decomposition). When QR_mode parameter is omitted or set to False, Excel's internal MINV function is used. The functions are otherwise backward compatible with existing spreadsheets.

Version 2.2 (02-Jun-2004)

- From this version on TriLookup will also work on **Excel for Macintosh** versions 98, 2001, and X.

- Fixed a bug in the TVPOLYDATA and THPOLYDATA functions that caused R^2 to be calculated as 1 when the actual value of R^2 was less than 0.01.
- Changed the way the best fit curve is determined by the TVPOLYDATA and THPOLYDATA functions. The curve with the maximum value of R^2 is selected as the best fit curve, as stated in TriLookup documentation. Previous versions picked the curve with the minimum $\text{Sum}(\text{Error}^2)$. While in most cases the maximum R^2 corresponds to the minimum $\text{Sum}(\text{Error}^2)$, sometimes the two don't coincide.
- TriLookup example workbooks were reformatted to use old style Forms controls instead of ActiveX controls on the worksheets. This solved compatibility issue on Macintosh and it also shortens the time required to open the example workbooks.
- A new combo box has been added to the worksheets in the Interactive Examples workbook which lets you select whether or not to hide the #N/A points on the line diagrams. The process of removing the #N/A points can take a long time on a slow computer.
- Starting in this version, the evaluation version of TriLookup will stop functioning after 30 days and all TriLookup functions will return the following message:

  ```
  "Error: TriLookup 30 day evaluation period expired!"
  ```

Version 2.1 (21-Mar-2004)

- A new parameter called ***Index_mode*** has been added to the TVLOOKUP, TVLKP, THLOOKUP, THLKP, TVPOLYDATA and THPOLYDATA functions. *Index_mode* is used to explicitly choose the way lookup and return rows/columns are selected: either by their titles (*Index_mode* = FALSE), or by their index number, i.e. the position in *Table_array* (*Index_mode* = TRUE).

  Note that in version 2.0 the way of identifying lookup and return rows/columns was not explicitly specified. Instead, identifying a row/column by its title took precedence over specifying it by its index number, which in some cases could have caused ambiguity regarding which row/column is being selected. This ambiguity has been eliminated with the addition of the *Index_mode* parameter.

  Note that *Index_mode* is the last parameter in the list, it is optional and its default value is FALSE. Therefore, the formulas created with TriLookup versions 1.x, (which only allows selecting lookup and return rows/columns by titles) will not be affected and can be used without modifications. However, the formulas created with TriLookup version 2.0 that implicitly use row/column selection by index number, have to be modified by setting *Index_mode* = TRUE.

Version 2.0 (19-Mar-2004)

- Thanks to Laurent Longre's FunCustomize.dll add-in, the problem described in section **Problem After Moving Workbooks with TriLookup Functions to Another Computer** was eliminated. The new workbooks will automatically reference TriLookup 2.0 if you refer to any of the TriLookup functions in the cell formulas. The references will stay valid after the workbook is moved from one computer to another.
- Thanks to Laurent Longre's FunCustomize.dll add-in, the **Formula Palette** dialog now also displays a short help message for each of the function parameters.

- In addition to identifying the lookup and return rows/columns by their titles, you can now also use the *Lookup_title* and *Return_title* parameters to specify the lookup and return rows/columns by their position in *Table_array* (1 for the first row/column, 2 for the second row/column, etc.). The affected functions are TVLOOKUP, TVLKP, THLOOKUP, THLKP, TVPOLYDATA and THPOLYDATA.
- The TriLookup functions now appear in a separate **TriLookup** function category in the **Paste Function** dialog.
- Fixed the bug that caused T2LOOKUP, T2LKP, T3LOOKUP and T3LKP functions to return a #VALUE error when the number of rows multiplied by the number of columns exceeded 32767.

Version 1.2 (15-Jan-2004)

- The setup program will now also install TriLookup for Excel 2003 in addition to Excel 97, 2000 and 2002 (XP).
- Fixed a bug in handling extrapolation for *Interpolate* (*X/Y/Z_interpolate*) = 6, when the values of the last three points in the series (the ones used to calculate the extrapolated result) are not uniformly ascending or uniformly descending, i.e., they produce a local maximum or a local minimum.

  Versions 1.0 and 1.1 return Excel's #VALUE error, even for *Error_msg* = TRUE.

  Version 1.2 returns a #N/A error, or if *Error_msg* = TRUE the following error message:

  ```
  "N/A {Err.315} Cannot extrapolate for Interpolate = 6, when the end 3-point segment
        has a minimum or a maximum."
  ```
- Changed the way extrapolation is performed when *Interpolate* (*X/Y/Z_interpolate*) = 6.

  Versions 1.0 and 1.1 extrapolate by extending the hyperbolic curve defined by the end 3-point segment. Due to divergent nature of the hyperbolic curve, this usually leads to highly unpredictable results.

  Version 1.2 extrapolates by extending the tangent drawn through the end point of the hyperbolic curve defined by the end 3-point segment. The extrapolated values now lie on a straight line, which makes the results of extrapolation much more predictable.
- Fixed a bug in the **Interactive Examples** workbook which prevented hiding of the #N/A points on the line graphs.

Version 1.1 (29-Sep-2003)

- Added switching to manual calculation when loading interactive example to avoid recalculation.
- Fixed a bug in processing tables with constant Y values in TVPOLYDATA and THPOLYDATA.

Version 1.0 (26-Mar-2003)

- Initial release of TriLookup.

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How to Register

We offer online registration on our homepage:
http://www.trimill.com/TriLookup/Register.htm

We use PayPal service for all credit card orders.

We will send your registration information via e-mail **within 48 hours of registering**. Click on the [**Enter Registration Code**] button in the TriLookup start-up window (shown every time you start Excel) and you will be prompted to enter your **Registered User Name** and the corresponding **Registration Code**. Once entered, the startup screen will be disabled and your User Name will be displayed in the **About TriLookup** window (select **Help | TriLookup Help | About** from Excel's menu).

You will also receive a receipt for your records, indicating that the program is properly registered. For multi-user and/or networked versions, a hard copy of the site license certificate can be requested for your records.

After registering your copy of TriLookup, you will have free access to all future revisions and versions of this program.

Personal License

A personal license costs 20 USD or 20 EUR or 30 CAD.

The registered version may be installed on as many computers as desired, as long as it is used by only one person at any one time (I.e. one installation at home and one at the office used by the same person). The usage by multiple people at the same time (on multiple computers) requires additional licenses.

See TriLookup Software License for more details.

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Additional licenses allow an institution, company or school to install the program on multiple computers or on a server. All licenses are issued to the same (company) name, which appears in the **About TriLookup** dialog. The program must not run on more machines at the same time than there are licenses purchased.

The cost of TriLookup licenses is as follows:

• 1st license	USD 20.- / Eur 20.- / CAD 30.-	
• 2nd – 10th license	USD 10.- / Eur 10.- / CAD 15.-	for each additional license
• 11th – 25th license	USD 8.- / Eur 8.- / CAD 12.-	for each additional license

- 26th – 100th license USD 6.- / Eur 6.- / CAD 9.- for each additional license
- 101st – 1000th license USD 4.- / Eur 4.- / CAD 6.- for each additional license

For larger amounts than 1000 please contact us by e-mail to info@trimill.com.

Examples for calculating additional licenses:

- License for 5 users: 20. + 4x10. = **USD 40.-**
- License for 10 users: 20. + 9x10. = **USD 110.-**
- License for 15 users: 20. + 9x10. + 5x8. = **USD 150.-**
- License for 25 users: 20. + 9x10. + 15x8. = **USD 230.-**
- License for 50 users: 20. + 9x10. + 15x8. + 25x6. = **USD 380.-**
- License for 100 users: 20. + 9x10. + 15x8. + 75x6. = **USD 680.-**
- License for 250 users: 20. + 9x10. + 15x8. + 75x6. + 150x4. = **USD 1280.-**

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Example: License extension from a 5 user license to a 30 user license:

5x10. + 15x8. + 5x16. = USD 200.-

If you have any questions, please ask by e-mail to info@trimill.com. At your request, we can send you a special order form for additional licenses by e-mail.

Installing and Uninstalling TriLookup

For the sake of clarity, the reminder of this document refers only to TriLookup. Unless TriLookupLite is specifically mentioned, whatever applies to TriLookup also applies to TriLookupLite.

Installing TriLookup

TriLookup 32 Win

This implementation of TriLookup can be installed on **32 bit Excel** versions 97 - 2016 for Windows (any version of Windows, both 32 bit and 64 bit).

To install TriLookup on a Windows computer with 32 bit Excel please follow the procedure outlined below:

- Save the setup file **TriLookup_32_Win_XX_Setup.exe** to any folder on your computer.
  Note that XX indicates TriLookup version number, for example, 30 means version 3.0.
- Close all running programs. In particular, **be sure to close Excel** before trying to install TriLookup!
- Run the TriLookup Setup program (double-click on the **TriLookup_32_Win_XX_Setup.exe** in the Windows explorer or run it through the Windows **Start | Run...** dialog), and follow the prompts.
- The Setup program will install **TriLookup.xla** add-in files and optional online help and example files in the folder that you specify.
- After the Setup program has successfully completed the installation, you can start Excel. TriLookup add-in will be **installed** and **loaded** in all supported versions of 32 bit Excel that are installed on your computer.

TriLookup 64 Win

This implementation of TriLookup can be installed on **64 bit Excel** versions 2007 - 2016 for Windows (any version of 64 bit Windows).

To install TriLookup on a Windows computer with 64 bit Excel please follow the procedure outlined below:

- Save the setup file **TriLookup_64_Win_XX_Setup.exe** to any folder on your computer.
  Note that XX indicates TriLookup version number, for example, 30 means version 3.0.
- Close all running programs. In particular, **be sure to close Excel** before trying to install TriLookup!
- Run the TriLookup Setup program (double-click on the **TriLookup_64_Win_XX_Setup.exe** in the Windows explorer or run it through the Windows **Start | Run...** dialog), and follow the prompts.
- The Setup program will install **TriLookup.xla** add-in files and optional online help and example files in the folder that you specify.

- After the Setup program has successfully completed the installation, you can start Excel. TriLookup add-in will be **installed** and **loaded** in all supported versions of 64 bit Excel that are installed on your computer.

TriLookup Mac

This implementation of TriLookup can be installed on **Mac Excel** versions 98 or through 2016 for Macintosh (with the exception of Mac Excel version 2008, which doesn't support VBA).

To install TriLookup on a Macintosh computer with Mac Excel please follow the procedure outlined below:

- Save the zip file **TriLookup_Mac_XX.zip** to any folder on your computer.
  Note that XX indicates TriLookup version number, for example, 30 means version 3.0.
- Unzip (expand) the contents of **TriLookup_Mac_XX.zip** to a new separate folder on your Hard Drive.
- Start Excel and navigate to the **Add-Ins** dialog (File | Options | Add-ins | Manage Excel Add-ins -> [Go])
- Click [Browse], go to the folder into which you have extracted the contents of the TriLookup_Mac_XX.zip file, select **TriLookup.xla** and click [Open].

How to Enable Help in Windows Vista, 7, 8, 8.1 and 10

TriLookup Help (only available in the TriLookup 32 Win implementation) was written for the old Windows Help program (WinHlp32.exe), which starting from Windows Vista is no longer included in the Windows installation package. Luckily, it can still be downloaded from Microsoft for Windows Vista, 7, 8 and 8.1 from https://support.microsoft.com/en-ca/kb/917607.

As of September 3, 2016, Microsoft hasn't yet released the version of WinHlp32.exe compatible with Windows 10. However, Here is a solution (thanks to Komeil Bahmanpour):

- Go to his site: www.komeil.com/blog/windows-help-program-winhelp-winhlp32-exe
- Download **winhlp32-windows-7-x86-x64-komeil.cab**: www.komeil.com/download/1230
- Unpack the winhlp32-windows-7-x86-x64-komeil.cab file to a temporary folder. It contains the following three files: Install.cmd, winhlp32.exe, winhlp32.exe.mui.
- Edit the **install.cmd** and add the following two lines to the '**settings**' section (yes, 'WindowsVersion=7' is correct):

  ```
  set WindowsVersion=7
  goto :BypassVersionError
  ```
- Save the **install.cmd** file, right click on in in Windows Explorer and select **Run it as administrator**.

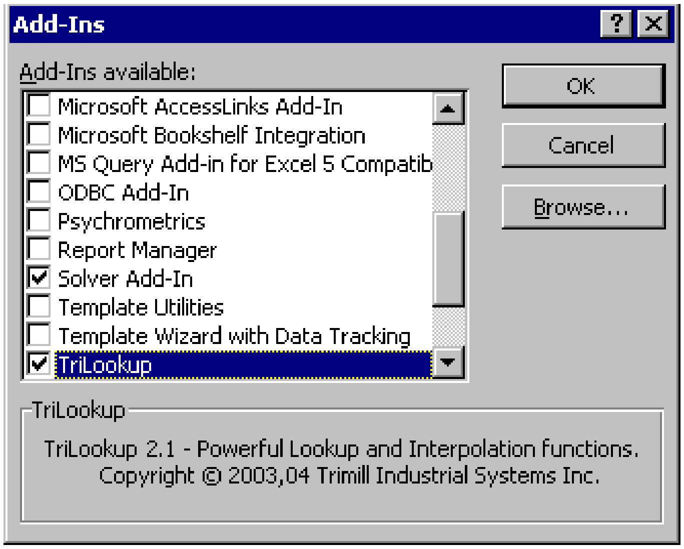
After this, you should be able to display TriLookup Online Help (and any other legacy help file) in Windows 10.

Loading TriLookup Using Excel's Add-in Manager

If you have previously unloaded TriLookup but haven't uninstalled it from your computer, you can load it again using Excel's add-in manager.

To load TriLookup, please follow the procedure outlined below:

- On the **Tools** menu, click **Add-Ins**.
- In the **Add-Ins available** box, select the check box next to **TriLookup** and then click the [OK] button.



TriLookup 2.1 - Powerful Lookup and Interpolation functions.
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Unloading TriLookup Using Excel’s Add-in Manager

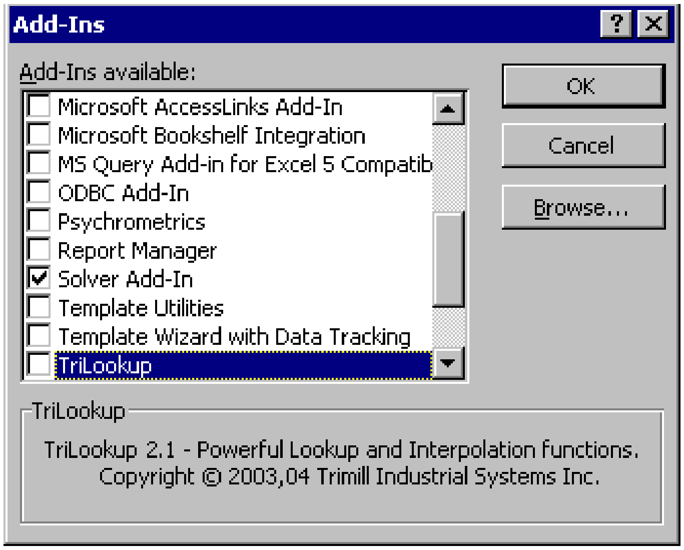
If you are not using the TriLookup add-in often, you can unload it to conserve memory and reduce the time it takes to start Excel. Unloading TriLookup removes its custom functions from Excel, but the TriLookup add-in program remains installed on your computer so you can easily load it again.

You should also unload TriLookup before permanently uninstalling it.

Note: When you unload the TriLookup add-in from Microsoft Excel, it is not removed from your computer system.

To unload TriLookup, please follow the procedure outlined below:

- On the **Tools** menu, click **Add-Ins**.
- In the **Add-Ins available** box, clear the check box next to **TriLookup** and then click the [OK] button.



Add-Ins available:

☐ Microsoft AccessLinks Add-In
☐ Microsoft Bookshelf Integration
☐ MS Query Add-in for Excel 5 Compatib
☐ ODBC Add-In
☐ Psychrometrics
☐ Report Manager
☑ Solver Add-In
☐ Template Utilities
☐ Template Wizard with Data Tracking
☐ TriLookup

TriLookup

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Permanently Uninstalling TriLookup

TriLookup 32 Win and TriLookup 64 Win

To uninstall TriLookup 32 Win or TriLookup 64 Win and permanently remove it from a Windows computer please follow the procedure outlined below:

Step 1

- Unload TriLookup using Excel's add-in manager. This is not a necessary step, but it is highly recommended in order to avoid a **File not found** error message next time you start Excel.
- Close Excel if it is running.

Step 2

Option a)

- Click the Windows **Start** button, point to **Settings**, and then click **Control Panel**.
- Double-click the **Add/Remove Programs** icon.
- Click **Trimill TriLookup** on the **Install/Uninstall** tab, and then click **Add/Remove**.
- Confirm that you wish to uninstall TriLookup and all of its components by clicking on the [Yes] button.

Option b)

- Click the Windows **Start** button, point to **Programs | TriLookup**, and click on **Uninstall TriLookup**.
- Confirm that you wish to uninstall TriLookup and all of its components by clicking on the [Yes] button.

TriLookup Mac

To uninstall TriLookup Mac and permanently remove it from a Macintosh computer please follow the procedure outlined below:

- Unload TriLookup using Excel's add-in manager.
- Find the folder in which you installed TriLookup and move it to trash.
- On Excel's **Tools** menu, click **Add-Ins** and in the **Add-Ins available** box, select the check box next to **TriLookup**.
- Answer **Yes** when asked whether to delete TriLookup.xla from the list.

Using TriLookup

Introduction to TriLookup

For latest news, see http://www.trimill.com/TriLookup

What is TriLookup?

TriLookup is an add-in for Microsoft® Excel for Windows version 97 or higher and Excel for Macintosh version 98 or higher (except version 2008). When installed, TriLookup adds eleven powerful lookup and interpolation worksheet functions to Excel, which offer greatly enhanced functionality compared to Excel's built-in lookup functions. You can use them to perform simple table lookup, as well as, interpolation and extrapolation from tables with one, two or three independent variables.

All TriLookup functions can be accessed through Excel’s **Function Wizard** (select **Function...** from the **Inset** worksheet menu, or click on the **Paste Function** button fx in the standard toolbar). See **Using TriLookup Functions in Excel Worksheets** for details.

TriLookup add-in package includes a comprehensive online help and a couple of example spreadsheets that demonstrate the capabilities and the proper usage of the added functions. You can access the online help and example files by selecting **TriLookup Help** from Excel’s **Help** menu. See TriLookup Online Help and Examples for details.

TriLookup It is written entirely in Visual Basic for Applications (VBA).

Do I Need TriLookup?

You will benefit from using TriLookup if your requirements go beyond the limited capabilities of the built-in Excel’s lookup functions (MATCH, LOOKUP, VLOOKUP and HLOOKUP) and/or if you wish to use Excel to fit polynomial curves through sets of X-Y points. For example, you may have encountered some of the following problems:

- Excel’s HLOOKUP and VLOOKUP built-in functions require that you specify the sequential number of the table row or column containing the data. Therefore, if you later modify your lookup table by inserting or deleting rows or columns, you must remember to go back and update the row/column numbers in the formulas using HLOOKUP and VLOOKUP functions. Otherwise, you may get the #VALUE! errors, or incorrect results by inadvertently retrieving data from unintended rows or columns.

- If you have an error in a cell formula using the built-in lookup functions, you will probably receive an Excel error code, such as #VALUE! or #N/A. Since you get no explanation about what caused the error, you can spend a lot of time trying to debug it.

- Excel’s built-in lookup functions cannot retrieve an interpolated value when the lookup value falls in-between the values that are given in the lookup table. At best, you can get an “approximate match”, described in Excel’s help topic for VLOOKUP as *“... approximate match is returned. In other words, if an exact match is not found, the next largest value that is less than lookup_value is returned”*. For example, if the lookup column contains values ... 1, 10, 100, 1000 ... and your lookup value is 99, then the “approximate match” will return the table value for 10.

- If you have a 2D lookup table in which the return values depend on two lookup variables, X and Y, you have to use a convoluted formula to retrieve a value from the table, for example:

  `=INDEX(LookupTable,MATCH(Y_value,LeftColumn,1),MATCH(X_value,TopRow,1))`

  Notice that in order to accomplish this simple task, you need to enter three lookup functions and separately reference three ranges of cells (one for the whole lookup table, one for the leftmost column and one for the topmost row). However, if there is no exact match for both X and Y lookup values, the best you can get is an “approximate match”, as described in the paragraph above.
- Suppose that you have a 3D lookup table (made up of a series of 2D lookup tables) in which the return values depend on three lookup variables, X, Y and Z. While it is still possible to use Excel’s lookup and reference functions to retrieve a value from a 3D table, it requires that you use a separate cell with a formula similar to the one in the paragraph above to perform X-Y lookup in each component 2D table, and then use an additional cell formula to perform Z lookup. Again, if there is no exact match for X, Y and Z lookup values, you can only get an “approximate match”, as described above.
- Even if you have a 4D table (made up of a series of 3D lookup tables) in which the return values depend on four lookup variables, X, Y, Z and D4 (4^{th} dimension), you can use a combination of T3LOOKUP and TVLOOKUP functions to retrieve an interpolated value.
- If you want to fit a polynomial curve through a set of X-Y points you can, in theory, find its coefficients it by using Excel’s built-in TREND and LINEST functions. In practice, however, you will probably give up before you get this method to work. Alternatively, you can insert an X-Y chart using the table data as a source, then add a polynomial trendline, display its equation on chart, cut and paste the trendline equation into a cell, and after some editing obtain a working formula for the polynomial curve. In addition to the number of steps involved, the problem with this method is that the maximum polynomial order that you can use is 6.

If you have encountered any of the difficulties described above, then you should find TriLookup functions helpful in your work.

TriLookup Functions Feature Highlights

- TVLOOKUP (TVLKP) and THLOOKUP (THLKP) functions are enhanced versions of Excel’s VLOOKUP and HLOOKUP built-in functions. They allow you to assign any column or row of a rectangular cell range as a lookup and return row/column, by simply specifying the row/column title or its index (number).
- T2LOOKUP and T2LKP functions allow you to retrieve values from 2D tables that have two independent variables, X and Y.
- T3LOOKUP and T3LKP functions allow you to retrieve values from 3D tables that have three independent variables, X, Y and Z.
- Depending on the values of optional parameters, all TriLookup functions listed above can calculate the return value by interpolating or extrapolating table values.

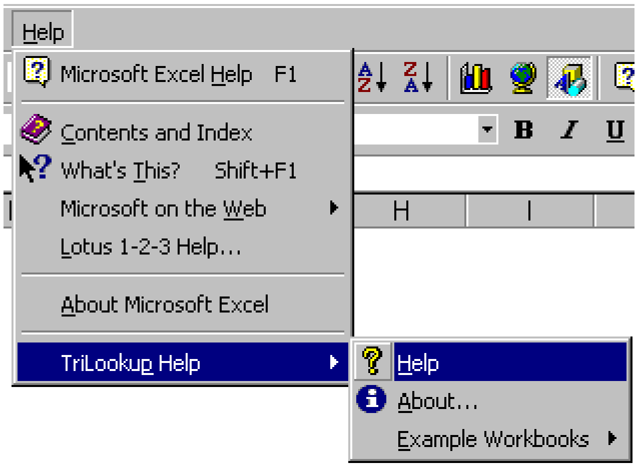
- Several modes of interpolation are available including closest value lookup, linear interpolation, curve interpolation using parabolic and hyperbolic piecewise curves, cubic splines and polynomial curves of order up to 20.
- TriLookup functions can process tables with missing and invalid values by either returning #N/A values in the areas of missing data, or by interpolating and extrapolating from the valid table values.
- TVPOLYDATA and THPOLYDATA functions allow you to easily determine polynomial curve coefficients, with order up to 20 (limited to 6 in TriLookupLite). The polynomial curves are fitted through the X-Y data points given in a multi-column or a multi-row table, using the least squares method.
- The TVPOLYDATA and THPOLYDATA functions automatically determine the best fit polynomial curve, with an option of taking into account the smoothness of the curve between the X-Y data points.
- TPOLY function calculates the return value (Y) of a Y = f(X) polynomial curve for a given lookup value (X) and an array of polynomial curve coefficients. Optionally, it can return the value of a derivative (1^{st}, 2^{nd}, 3^{rd}, etc) for the given lookup value (X).
- In case of an error, all TriLookup functions (except TPOLY) can either return a standard Excel error code (such as #NA or #VALUE!), or a detailed text error message indicating the nature of the error and pointing to the cause of it. This feature can be very helpful when debugging your spreadsheet.

TriLookup Help and Examples

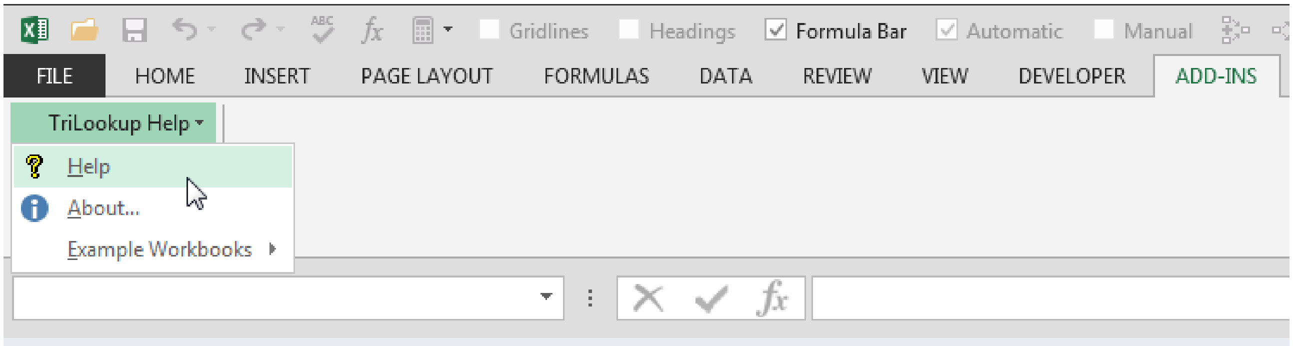
TriLookup add-in package includes the following online help and examples:

- Windows Help file (TriLookup.hlp) in the legacy WinHlp32 format.
- Two Excel workbooks with interactive and practical examples that demonstrate the capabilities and the proper usage of TriLookup functions.

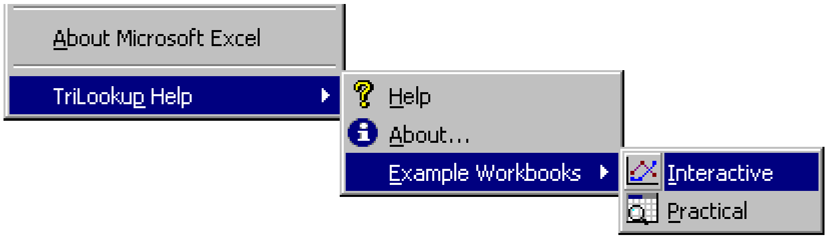
Once TriLookup is installed, the help file can be accessed from Excel by selecting **TriLookup Help** on the **Help** menu and then clicking **Help**.



In Excel 2007 and later, you can access TriLookup menus from the ADD-INS tab by clicking on **TriLookup Help**.



The interactive and practical example workbooks can be accessed by selecting **TriLookup Help** on the **Help** menu, then **Example Workbooks** and then clicking on **Interactive** or **Practical**.



Using TriLookup Functions in Excel Worksheets

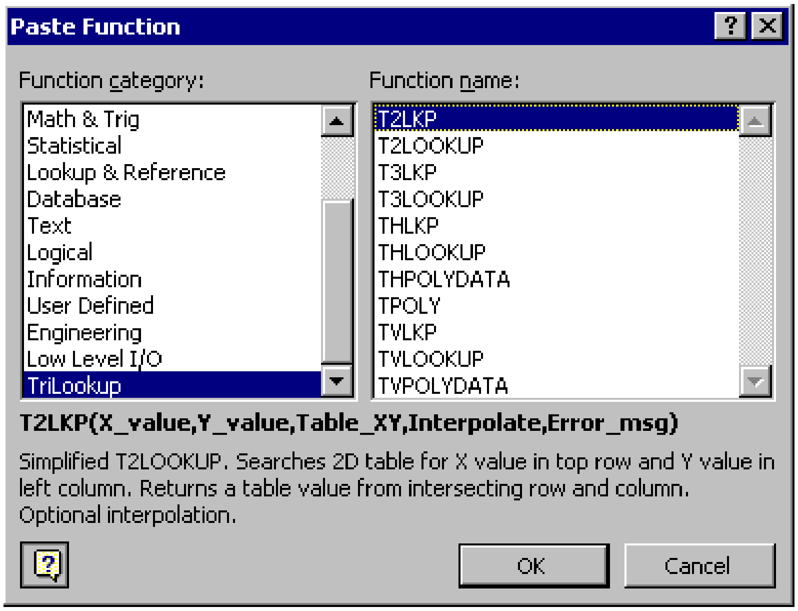
Once installed, TriLookup functions can be accessed by typing in the function name, followed by parameters in parentheses, into an Excel worksheet cell. For example, if you wish to use the T2LOOKUP function to retrieve interpolated values from a 2D X-Y lookup table, you could type the following formula into a cell:

```
=T2LOOKUP(5.5,0.9,$B$6:$E$10,4,4,1,,,,,,TRUE)
```

Another way of accessing TriLookup functions is to use Excel's **Paste Function** dialog by selecting **Function...** from the **Inset** worksheet menu, or by clicking on the **Paste Function** button located in the standard toolbar (in Excel 97 and 2000 only). Either way will activate the **Paste Function** dialog, which will let you interactively select the function you wish to use.

In the TriLookup 32 Win implementation all TriLookup functions are located in the separate **TriLookup** function category.

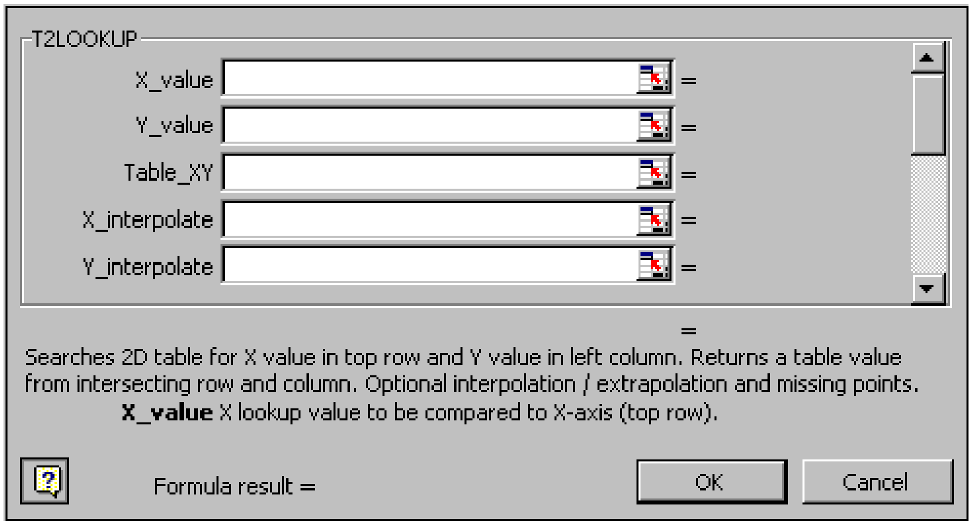
In the TriLookup 64 Win and TriLookup Mac implementations all TriLookup functions are located in the built-in **Lookup & Reference** function category.



T2LKP(X_value,Y_value,Table_XY,Interpolate,Error_msg)

Simplified T2LOOKUP. Searches 2D table for X value in top row and Y value in left column. Returns a table value from intersecting row and column. Optional interpolation.

After selecting the desired function and clicking on the [OK] button, you will be prompted to interactively enter the function parameters through Excel's **Formula Palette** dialog box:



Searches 2D table for X value in top row and Y value in left column. Returns a table value from intersecting row and column. Optional interpolation / extrapolation and missing points.

X_value X lookup value to be compared to X-axis (top row).

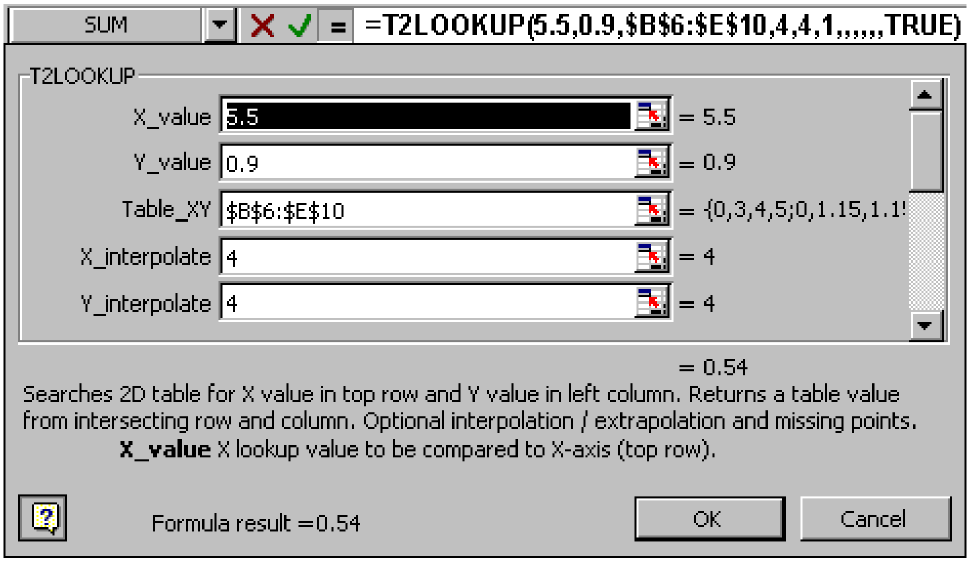
Formula result =

Note that the parameter help in the **Formula Palette** dialog box is only available in the TriLookup 32 Win implementation.

If you wish to change parameter values in a cell that already contains a TriLookup function, you can do that either manually by editing the cell formula text, or interactively by selecting the cell and then clicking on the **Paste Function** button fx. For example, if a cell contains the following formula:

```
=T2LOOKUP(5.5,0.9,$B$6:$E$10,4,4,1,,,,,,TRUE)
```

then selecting the cell and clicking on the **Paste Function** button fx will invoke the **Formula Palette** dialog box with the current values of the parameters already filled in:



=T2LOOKUP(5.5,0.9,$B$6:$E$10,4,4,1,,,,,,TRUE)

X_value 5.5 = 5.5

Y_value 0.9 = 0.9

Table_XY $B$6:$E$10 = {0,3,4,5;0,1.15,1.1!

X_interpolate 4 = 4

Y_interpolate 4 = 4

= 0.54

Searches 2D table for X value in top row and Y value in left column. Returns a table value from intersecting row and column. Optional interpolation / extrapolation and missing points.

X_value X lookup value to be compared to X-axis (top row).

Formula result =0.54

This method is especially useful for functions that have many optional parameters, such as T2LOOKUP and T3LOOKUP.

Problem After Moving Workbooks with TriLookup Functions to Another Computer

TriLookup 32 Win

Thanks to implementing Laurent Longre's FunCustomize.dll add-in, the problem described in this section was eliminated in the TriLookup 32 Win implementation. Any new workbooks you create will automatically link to TriLookup if you reference any of the TriLookup functions in cell formulas. The references will stay valid even after the workbook has been moved from one computer to another.

However, any existing workbooks that have explicit references to **TriLookup.xla** through the Visual Basic Editor (VBE) will continue to cause the problem described, as described in section **Using an Explicit Reference to TriLookup**.

TriLookup 64 Win and TriLookup Mac

Unfortunately, the above fix is unavailable for TriLookup 64 Win and TriLookup Mac. Therefore, the problem described in this section still applies to these two implementations of TriLookup.

The Problem

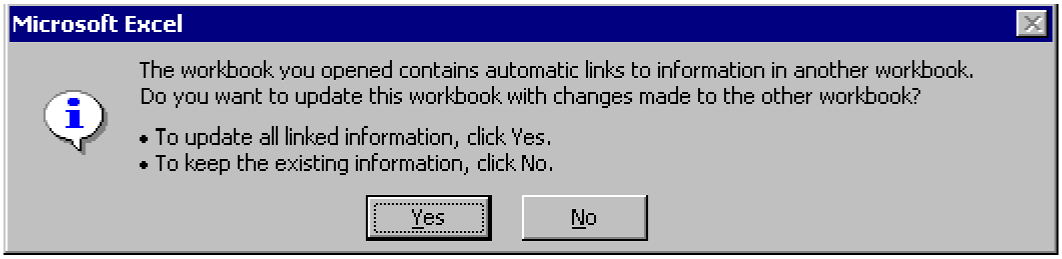
Due to inner workings of Excel, there is a potential problem when distributing workbooks that use any external add-in, including TriLookup. When moving or copying a worksheet that references TriLookup functions from one computer to another, you may encounter a problem with broken references (links) to TriLookup, even if the TriLookup add-in is properly installed and loaded on both computers.

Example of What Can Happen

Suppose that you have TriLookup installed on your computer and that you have created a workbook containing the following formula in one of the cells:

```
=TVLKP(0.75,$A$3:$D$8,"X2","Y1",4)
```

The above cell formula evaluates properly on your computer by referencing the TVLKP function. Next, you copy your workbook to another computer, which also has TriLookup installed. However, when you open the workbook on the other computer, Excel gives you the following error message:



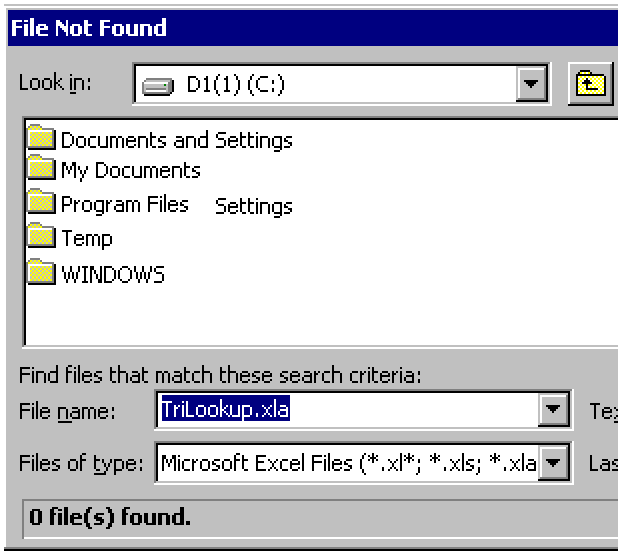
The workbook you opened contains automatic links to information in another workbook. Do you want to update this workbook with changes made to the other workbook?

- To update all linked information, click Yes.
- To keep the existing information, click No.

If you click on [No], the above cell referencing TVLKP (and any other cell referencing any other TriLookup function) will return the #NAME? error value. When you select the cell, you will see in the formula bar that the above formula has been changed and now reads something like:

```
='C:\Program Files\Trimill\TriLookup\TriLookup.xla'!TVLKP(0.75,$A$3:$D$8,"X2","Y1",4)
```

If you click on the [Yes] button in the above dialog box, you will be prompted to locate the locate TriLookup.xla on your computer:



File Not Found

Look in: D1(1) (C:)

Documents and Settings
My Documents
Program Files Settings
Temp
WINDOWS

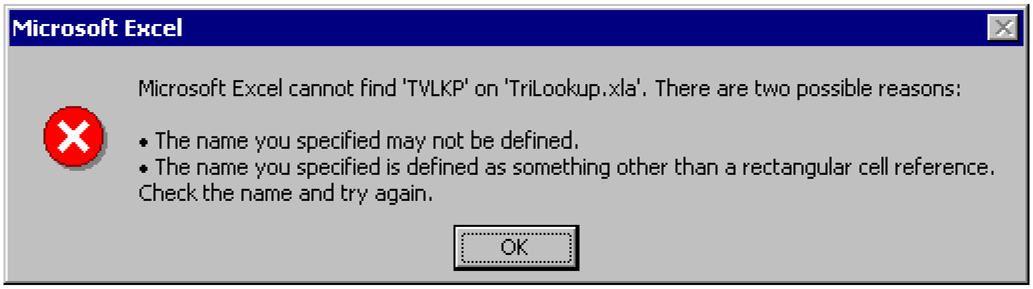
Find files that match these search criteria:

File name: TriLookup.xla

Files of type: Microsoft Excel Files (*.xl*; *.xls; *.xla

0 file(s) found.

Even if you go ahead and find TriLookup.xla, your troubles are not over yet! For some reason, Excel will not recognize that TVLKP is a custom function in TriLookup.xla, but will try to evaluate it as a workbook name and will, therefore, show you another error warning:



Microsoft Excel

Microsoft Excel cannot find 'TVLKP' on 'TriLookup.xla'. There are two possible reasons:

- The name you specified may not be defined.
- The name you specified is defined as something other than a rectangular cell reference.

Check the name and try again.

After you click on [OK], the cell referencing the TVLKP function will return the #NAME? error value and the cell formula will be changed to include the original path to TriLookup.xla.

When Will This Happen?

This problem will occur **if and only if** TriLookup is installed in different folders on the source and destination computers (for example, in “C:\Program Files\Trimill\TriLookup” on one computer and in “C:\Program Files\Excel Add-Ins” on the other computer).

Why Does This Happen?

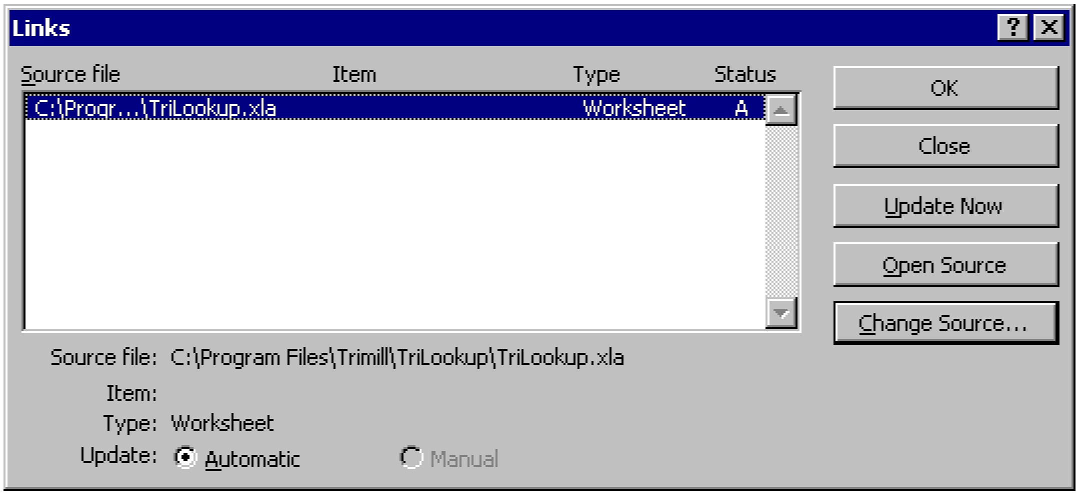
This is caused by the way Excel internally keeps record of references between workbooks. The problem is not unique to TriLookup, it affects all third party add-ins for Excel.

Temporary Solution 1

If you have only a few references to TriLookup functions in your workbook, you can manually edit the cell formulas and delete the hard coded TriLookup.xla path from them. You can also use Excel’s search and replace to delete the **'C:\Program Files\Trimill\TriLookup\TriLookup.xla'!** string from all of your worksheet formulas at once. That should fix the problem.

Temporary Solution 2

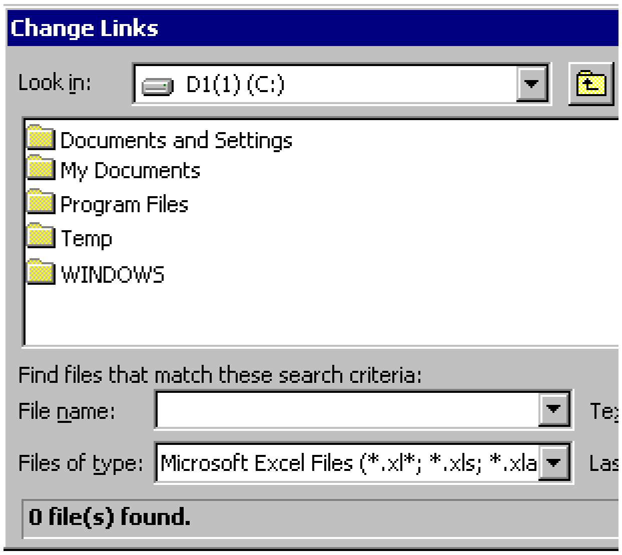
Another method of fixing the broken references is through the **Links** Excel dialog box. To access it, click **Links...** on the **Edit** menu.



Source file	Item	Type	Status
C:\Progr...\TriLookup.xla		Worksheet	A

Source file: C:\Program Files\Trimill\TriLookup\TriLookup.xla
Item:
Type: Worksheet
Update: ● Automatic ○ Manual

Then click on [**Change Source...**]. Excel will show the **Change Links** dialog that will prompt you to locate TriLookup.xla.



Look in: D1(1) (C:)

- Documents and Settings
- My Documents
- Program Files
- Temp
- WINDOWS

Find files that match these search criteria:
File name:
Files of type: Microsoft Excel Files (*.xl*; *.xls; *.xla

0 file(s) found.

Once you have located TriLookup.xla and confirmed your choice, the links to the TriLookup functions in your book will be updated

Permanent Solution

The downside of the two temporary solutions described above is that the same problem will occur every time you copy the workbook from one computer to another, which, in the long run, can become quite annoying. A permanent solution involves a bit more work, but it will probably be worth it.

To enable the workbook to automatically find the path to TriLookup on any computer on which TriLookup is installed, you need to **Use an Explicit Reference to TriLookup**, as described in the following section.

Using an Explicit Reference to TriLookup

You will need to use an explicit reference to TriLookup if:

- In the TriLookup 32 Win implementation, if you are having problems with broken links to TriLookup functions in any existing workbooks that were created using TriLookup version 1.x, as described in **Problem After Moving Workbooks with TriLookup Functions to Another Computer**.
- In the TriLookup Mac implementation, if you want to create a portable version of the workbook that can be moved or copied between computers, as described in **Problem After Moving Workbooks with TriLookup Functions to Another Computer**.
- You want to call TriLookup functions from VBA code, as described in **Using TriLookup Functions in VBA Code**.

In order to establish an explicit reference to TriLookup, follow the steps below:

1. Start Excel and create a new workbook (for example by pressing <Ctrl><N>).
2. Switch to Visual Basic Editor by pressing <Alt><F11> or by clicking on the toolbar button.
3. Locate the name of your workbook in the **Project Explorer** window and click on it.
4. On the **Tools** menu, click **References**.
5. In the **Available References** box, select the check box next to **TriLookup** and then click the [OK] button.
6. This step will allow you to move the workbook between computers without causing broken links to TriLookup functions:
   On the **Insert** menu click **Module**. Copy the VBA code below and paste it into the **Module1 (Code)** window:

```
Sub Auto_Open()
    GetTriLookupReference
End Sub

Sub GetTriLookupReference()
Dim TriLookupFileName As String
  Application.ScreenUpdating = False
  'Read the full path to TriLookup.xla from the Registry
  TriLookupFileName = GetSetting(appname:="Trimill", section:="TriLookup", _
      key:="FileName", Default:="")
  If TriLookupFileName = "" Then
    MsgBox "TriLookup Addin not installed."
    ThisWorkbook.Saved = True
    Exit Sub
  End If
  'Add a reference to TriLookup to this file using Registry info
  On Error GoTo TriLookupRefError
  ThisWorkbook.VBProject.References.AddFromFile TriLookupFileName
  Application.ScreenUpdating = True
  ThisWorkbook.Saved = False
  Exit Sub
TriLookupRefError:
  'Ignore error if the reference to TriLookup is already active
  If Err <> 32813 Then
    MsgBox Title:="TriLookup Reference", _
        Prompt:="Error: " & Err & ": " & Err.Description
 ThisWorkbook.Saved = True
  End If
  Application.ScreenUpdating = True
End Sub
```

7. Return to Excel by closing Visual Basic Editor or by pressing <Alt><F11>.
8. (**Optional**) At this point, you can save the file as an **Excel template (.xlt)**, so that in the future you can use the template for creating new workbooks, instead of going through the steps described above. This will ensure that the workbooks based on this template will be properly set to reference TriLookup and will have the required VBA code already built in.
9. You can now enter formulas using TriLookup functions. Save the workbook when you done.

Once the workbook referencing TriLookup functions is set up in this way, you can freely copy it from one computer to another without having to worry about broken references.

Note Regarding Excel for Windows Versions 2002 (XP) and higher

Opening a workbook containing the VBA code from **step 6** in Excel for Windows versions 2002 (XP) and higher will cause the following error message:

Error: 1004: Programmatic Access to Visual Basic Project is Not Trusted

Cause

Microsoft Excel 2002 introduced a new security feature that allows you to choose whether or not programmatic access to the Visual Basic project should be trusted. The default setting is to not trust programmatic access to the Visual Basic project.

The VBA code shown in step 6 above programmatically establishes a reference from the workbook that contains it to TriLookup.xla.

Solution

To allow programmatic access to TriLookup, and all other Visual Basic projects, follow these steps:

1. On the **Tools** menu, point to **Macro** and then click **Security**.
2. In the **Security** dialog box, click the **Trusted Sources** tab.
3. Click to select the **Trust Access to Visual Basic Project** check box.

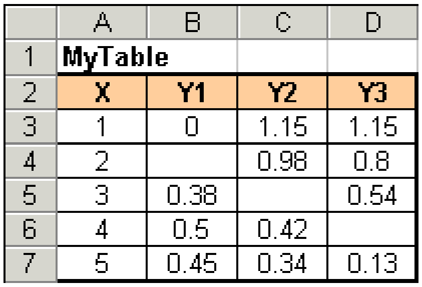
In case you don’t plan to use your workbook on different computers, you can also resolve this problem by skipping **step 6.**

Using TriLookup Functions in VBA Code

Once you have installed TriLookup, you can use its worksheet functions in your own VBA code. In order to do this, you must first establish a reference to TriLookup.xla from your workbook (see **Using an Explicit Reference to TriLookup**).

With a little bit of VBA programming, you can define your own custom worksheet functions based on TriLookup functions. This can be useful if plan to use many references to the same TriLookup function with the constant values for most of the parameters.

For example, suppose you have the following lookup table, with the name “MyTable” assigned to the cell range $A$2:$D$7:



	A	B	C	D
1	**MyTable**			
2	**X**	**Y1**	**Y2**	**Y3**
3	1	0	1.15	1.15
4	2		0.98	0.8
5	3	0.38		0.54
6	4	0.5	0.42	
7	5	0.45	0.34	0.13

Also, suppose that every time you lookup a value from the above table, you want to:

- Assign the column titled “X” as the lookup column;
- use double parabolic interpolation (*Interpolate* = 5) with curve averaging using a sine curve (*Power* = 0);
- extrapolate up to 0.5 units past minimum and maximum table lookup values (i.e., lookup for any values between 0.5 and 5.5);
- allow missing or invalid cells;
- return a detailed error message in case of an error.

To accomplish the above task, you can use the TVLOOKUP function in your cell formula. For example, assuming the lookup value of **0.75** and the return column title **Y1**, the corresponding cell formula would be:

```
=TVLOOKUP(0.75,MyTable,"X","Y1",5,0.5,0,TRUE,TRUE)
```

Since you plan to use this formula in many cells of your workbook, but only wish to change the lookup value and the title of the return column, you can simplify the cell formulas by creating your own custom sheet function using VBA. The custom function (named MyLookup in the example below) has only 2 parameters: *Lookup_value* and *Return_title*, while all other parameters that MyLookup passes to TVLOOKUP are kept constant.

The following VBA code defines the **MyLookup** custom sheet function, assuming that the range named **MyTable** is located in the worksheet named ‘**MyTable Sheet**’:

```
Function MyLookup(Lookup_value, Return_title)
Const Worksheet_name = "MyTable Sheet"
Const Table_array_name = "MyTable"
Const Lookup_title = "X"
Const Interpolate = 5
Const Extrapolate = 0.5
Const Power = 0#
Const Missing_pts = True
Const Error_Msg = True
```

```
  On Error GoTo SomethingWrong
  With ThisWorkbook.Worksheets(Worksheet_name)
    MyLookup = TVLOOKUP(Lookup_value, .Range(Table_array_name), Lookup_title, _
       Return_title, Interpolate, Extrapolate, Power, Missing_pts, Error_Msg)
  End With
  Exit Function

SomethingWrong:
  MyLookup = "#Error in Custom Function."
End Function
```

Assuming you have entered the above code into a VBA Code Module of the workbook named '**My Workbook.xls**' (which contains the worksheet named '**MyTable Sheet**' with the lookup table '**MyTable')**, you can now replace the following formula referencing TVLOOKUP:

`=TVLOOKUP(0.75,MyTable,"X","Y1",5,0.5,0,TRUE,TRUE)`

with the formula below referencing MyLookup:

`=MyLookup(0.75,"Y1")`

You can use this formula in all worksheets of 'My Workbook.xls'. You can also use the MyLookup function in other workbooks, by prefixing it with the workbook name:

`='My Workbook.xls'!MyLookup(0.75,"Y1")`

or by establishing the reference to 'My Workbook.xls' through **Tools | References** from the Visual Basic Editor menu.

Example

> TriLookup Practical Examples workbook contains two custom sheet functions in the VBA module mCustomFunctions: GasEnthalpy and GasTemperature. Both functions reference the lookup table 'EnthalpyTable' on the worksheet 'TVLOOKUP 2'. The same module also contains the Sub named GetTriLookupReference that can be used to automatically establish the reference to TriLookup.xla.

TriLookup Functions

Index of TriLookup Functions

TVLOOKUP

Searches a 2D multi column table for the lookup value in the lookup column and returns a value from the same row of the return column. It can use interpolation and can process missing or invalid values.

TVLKP

Simplified version of TVLOOKUP. Searches a 2D multi column table for the lookup value in the lookup column and returns a value from the same row of the return column. It can use interpolation.

THLOOKUP

Searches a 2D multi row table for the lookup value in the lookup row and returns a value from the same column of the return row. It can use interpolation and can process missing or invalid values.

THLKP

Simplified version of THLOOKUP. Searches a 2D multi row table for the lookup value in the lookup row and returns a value from the same column of the return row. It can use various types of interpolation.

T2LOOKUP

Searches a 2D (X-Y) table for X values in topmost row and Y values in leftmost column, and returns a value from the intersecting row and column. It can use interpolation and can process missing or invalid values.

T2LKP

Simplified version of T2LOOKUP. Searches a 2D (X-Y) table for X values in topmost row and Y values in leftmost column, and returns a value from the intersecting row and column. It can use interpolation.

T3LOOKUP

Searches a 3D (X-Y-Z) table for X, Y and Z values. Returns a value V(x,y,z) from the intersecting row, column and table. It can use interpolation and can process missing or invalid values.

T3LKP

Simplified version of T3LOOKUP. Searches a 3D (X-Y-Z) table for X, Y and Z values. Returns a value V(x,y,z) from the intersecting row, column and table. It can use interpolation.

TVPOLYDATA

Calculates polynomial curve coefficients up to a specified order (using the least squares method) for the X-Y data points given in a multi-column table. It also determines the best fit curve.

THPOLYDATA

Calculates polynomial curve coefficients up to a specified order (using the least squares method) for the X-Y data points given in a multi-row table. It also determines the best fit curve.

TPOLY

Returns the Y value of a polynomial curve for given a lookup value (X), polynomial order and an array of polynomial curve coefficients. It can optionally return the value of a derivative.

TVLOOKUP

Identifies lookup column and return column of a 2D multi column table by searching for the specified lookup and return titles in the topmost row of the table, or by column index numbers; then searches for the specified lookup value in the lookup column and returns a value from the same row of the return column. Depending on optional parameters, it can calculate the return value by interpolating or extrapolating table values. If desired, it can also process tables with missing or invalid values.

Syntax

TVLOOKUP (**Lookup_value**, **Table_array**, **Lookup_title**, **Return_title**, Interpolate, Extrapolate, Power, Missing_pts, Error_msg, Index_mode)

Lookup_value For *Interpolate* = 0, 1, or 2 it is the numeric or text value to be found in the lookup column; for *Interpolate* < 0 or *Interpolate* > 2 it is a numeric value that is compared to the values in the lookup column and for which an interpolated value from the return column is calculated.

Table_array is the lookup table. It is a single area rectangular range of cells that contains lookup column and return column. The first (topmost) row contains column titles. *Table_array* must contain a minimum of 2 rows and 2 columns. It can also be a reference to a range name.

Lookup_title For *Index_mode* = FALSE it is the exact value (numeric or text - not case sensitive) to be found in the first (topmost) row of the lookup table in order to identify the lookup column. TVLOOKUP searches this column for the specified lookup value. Any column in the *Table_array* can be specified as the lookup column.

For *Index_mode* = TRUE it specifies the lookup column index number (position of the lookup column in *Table_array*: 1 for the first column, 2 for the second column, etc.).

Return_title For *Index_mode* = FALSE is the exact value (numeric or text - not case sensitive) to be found in the first (topmost) row of the lookup table in order to identify the return column. TVLOOKUP returns the value from this column, or uses it to calculate the interpolated return value. Any column in the *Table_array* can be specified as the return column.

For *Index_mode* = TRUE it specifies the return column index number (position of the return column in *Table_array*: 1 for the first column, 2 for the second column, etc.).

Interpolate Optional, whole number between -20 and 7 (0 to 4 in TriLookupLite), default = 0. It is the type of interpolation to be used in determining the return value. The following types of interpolation can be used:

0 Exact match only (default);
1 Exact or next lower value;
2 Exact or next higher value;
3 Closest value;
4 Linear interpolation;
5 Double parabolic piecewise curve interpolation;
6 Double hyperbolic piecewise curve interpolation;

7 Cubic spline curve interpolation;
-1 to -20 Polynomial curve interpolation (order n = -*Interpolate*);

For *Interpolate* <> 0, the values in the lookup column must be constantly ascending or descending. For example, the following array of values is invalid: 2, 3, 3, 4.
For *Interpolate* < 0 or *Interpolate* > 2, the values in both lookup column and return column must be numeric.

Extrapolate Optional, any number, default = 0 (no extrapolation). Determines whether to perform extrapolation and the size of extrapolation interval (how far to extrapolate past the minimum and maximum values in the lookup column). The following values can be used:
0 Do not extrapolate;
> 0 Extrapolate, extrapolation interval = *Extrapolate*
< 0 Extrapolate, extrapolation interval = *Extrapolate* * (LCmin – LCmax)
(LCmax and LCmin are maximum and minimum values in the lookup column, respectively).

The size of extrapolation interval also determines how the missing points will be processed. See *Missing_pts* and *Extrapolate* for details.
Extrapolation can only be done on numeric values, and if *Interpolate* < 0 or *Interpolate* > 2.

Power Optional, any number, default = 1. This is the exponent used for averaging in double parabolic interpolation (*Interpolate* = 5) and double hyperbolic interpolation (*Interpolate* = 6). The weight used for averaging between the left and the right curve is raised to this power. In a special case for *Power* = 0 the averaging weight is calculated using a sine curve.

Missing_pts Optional, TRUE or FALSE, default = FALSE. Determines whether to allow blank and non-numeric cells in the lookup column and return column. It has no effect when *Interpolate* = 0. In that case the table may contain any values.
FALSE blank and non-numeric cells are NOT allowed;
TRUE blank and non-numeric cells are allowed. How the table with missing points (blank and non-numeric cells) will be processed also depends on the extrapolation interval.

Error_msg Optional, TRUE or FALSE, default = FALSE. In case of an error, it determines whether or not to return a detailed text error message indicating the cause of the error instead of a standard Excel error code (such as #NA or #VALUE!).
FALSE return a standard Excel error code;
TRUE return a detailed text error message.

Index_mode Optional, TRUE or FALSE, default = FALSE. It determines the way *Lookup_title* and *Return_title* are used to select the lookup and return columns.
FALSE select the lookup and return columns by the column titles;
TRUE select the columns by the column index numbers (positions in *Table_array*). In this case the column titles in the topmost row of *Table_array* are ignored.

Remarks

- If you do NOT need to extrapolate, or process tables with blank and non-numeric cells, you can also use the simplified TVLKP function. It uses default values for the following parameters:
  Extrapolate = 0 (no extrapolation);
  Power = 1 (linear curve averaging for *Interpolate* = 5 and *Interpolate* = 6);
  Missing_pts = FALSE (blank and non-numeric cells are NOT allowed).
- Use THLOOKUP instead of TVLOOKUP when your lookup and return values are located in table **rows**.

TVLKP

TVLKP is a simplified version of TVLOOKUP function that uses default parameter values. It identifies lookup column and return column of a 2D multi column table by searching for the specified lookup and return titles in the topmost row of the table, or by column index numbers; then searches for the specified lookup value in the lookup column and returns a value from the same row of the return column. Depending on an optional parameter, it can calculate the return value by interpolating table values.

Syntax

TVLKP (Lookup_value, Table_array, Lookup_title, Return_title, Interpolate, Error_msg, Index_mode)

Lookup_value For *Interpolate* = 0, 1, or 2 it is the numeric or text value to be found in the lookup column; for *Interpolate* < 0 or *Interpolate* > 2 it is a numeric value that is compared to the values in the lookup column and for which an interpolated value from the return column is calculated.

Table_array is the lookup table. It is a single area rectangular range of cells that contains lookup column and return column. The first (topmost) row contains column titles. *Table_array* must contain a minimum of 2 rows and 2 columns. It can also be a reference to a range name.

Lookup_title For *Index_mode* = FALSE it is the exact value (numeric or text - not case sensitive) to be found in the first (topmost) row of the lookup table in order to identify the lookup column. TVLKP searches this column for the specified lookup value. Any column in the *Table_array* can be specified as the lookup column.

For *Index_mode* = TRUE it specifies the lookup column index number (position of the lookup column in *Table_array*: 1 for the first column, 2 for the second column, etc.).

Return_title For *Index_mode* = FALSE it is the exact value (numeric or text - not case sensitive) to be found in the first (topmost) row of the lookup table in order to identify the return column. TVLKP returns the value from this column, or uses it to calculate the interpolated return value. Any column in the *Table_array* can be specified as the return column.

For *Index_mode* = TRUE it specifies the return column index number (position of the return column in *Table_array*: 1 for the first column, 2 for the second column, etc.).

Interpolate Optional, whole number between -20 and 7 (0 to 4 in TriLookupLite), default = 0. It is the type of interpolation to be used in determining the return value. The following types of interpolation can be used:

0 Exact match only (default);
1 Exact or next lower value;
2 Exact or next higher value;
3 Closest value;
4 Linear interpolation;
5 Double parabolic piecewise curve interpolation;
6 Double hyperbolic piecewise curve interpolation;

7 Cubic spline curve interpolation;
-1 to -20 Polynomial curve interpolation (order n = -*Interpolate*);

For *Interpolate* <> 0, the values in the lookup column must be constantly ascending or descending. For example, the following array of values is invalid: 2, 3, 3, 4.
For *Interpolate* < 0 or *Interpolate* > 2, the values in both lookup column and return column must be numeric.

Error_msg Optional, TRUE or FALSE, default = FALSE. In case of an error, it determines whether or not to return a detailed text error message indicating the cause of the error instead of a standard Excel error code (such as #NA or #VALUE!).
FALSE return a standard Excel error code;
TRUE return a detailed text error message.

Index_mode Optional, TRUE or FALSE, default = FALSE. It determines the way *Lookup_title* and *Return_title* are used to select the lookup and return columns.
FALSE select the lookup and return columns by the column titles;
TRUE select the columns by the column index numbers (positions in *Table_array*). In this case the column titles in the topmost row of *Table_array* are ignored.

Remarks

- TVLKP is a simplified version of the TVLOOKUP function. It uses default values for the following parameters:
  Extrapolate = 0 (no extrapolation);
  Power = 1 (linear order curve averaging for *Interpolate* = 5 and *Interpolate* = 6);
  Missing_pts = FALSE (blank and non-numeric cells are NOT allowed).
- If you need to extrapolate, or process tables with blank and non-numeric cells, you must use the TVLOOKUP function.

THLOOKUP

Identifies lookup row and return row of a 2D multi row table by searching for the specified lookup and return titles in the leftmost column of the table, or by row index numbers; then searches for the specified lookup value in the lookup row and returns a value from the same column of the return row. Depending on optional parameters, it can calculate the return value by interpolating or extrapolating table values. If desired, it can also process tables with missing or invalid values.

Syntax

THLOOKUP (**Lookup_value**, **Table_array**, **Lookup_title**, **Return_title**, Interpolate, Extrapolate, Power, Missing_pts, Error_msg, Index_mode)

Lookup_value For *Interpolate* = 0, 1, or 2 it is the numeric or text value to be found in the lookup row; for *Interpolate* < 0 or *Interpolate* > 2 it is a numeric value that is compared to the values in the lookup row and for which an interpolated value from the return row is calculated.

Table_array is the lookup table. It is a single area rectangular range of cells that contains lookup row and return row. The first (leftmost) column contains row titles. *Table_array* must contain a minimum of 2 rows and 2 columns. It can also be a reference to a range name.

Lookup_title For *Index_mode* = FALSE it is the exact value (numeric or text - not case sensitive) to be found in the first (leftmost) column of the lookup table in order to identify the lookup row. THLOOKUP searches this row for the specified lookup value. Any row in the *Table_array* can be specified as the lookup row.

For *Index_mode* = TRUE it specifies the lookup row index number (position of the lookup row in *Table_array*: 1 for the first row, 2 for the second row, etc.).

Return_title For *Index_mode* = FALSE it is the exact value (numeric or text - not case sensitive) to be found in the first (leftmost) column of the lookup table in order to identify the return row. THLOOKUP returns the value from this row, or uses it to calculate the interpolated return value. Any row in the *Table_array* can be specified as the return row.

For *Index_mode* = TRUE it specifies the return row index number (position of the return row in *Table_array*: 1 for the first row, 2 for the second row, etc.).

Interpolate Optional, whole number between -20 and 7 (0 to 4 in TriLookupLite), default = 0. It is the type of interpolation to be used in determining the return value. The following types of interpolation can be used:

0 Exact match only (default);
1 Exact or next lower value;
2 Exact or next higher value;
3 Closest value;
4 Linear interpolation;
5 Double parabolic piecewise curve interpolation;
6 Double hyperbolic piecewise curve interpolation;
7 Cubic spline curve interpolation;
-1 to -20 Polynomial curve interpolation (order n = -*Interpolate*).

For *Interpolate* <> 0, the values in the lookup row must be constantly ascending or descending. For example, the following array of values is invalid: 2, 3, 3, 4.
For *Interpolate* < 0 or *Interpolate* > 2, the values in both lookup row and return row must be numeric.

Extrapolate Optional, any number, default = 0 (no extrapolation). Determines whether to perform extrapolation and the size of extrapolation interval (how far to extrapolate past the minimum and maximum values in the lookup row). The following values can be used:
0 Do not extrapolate;
> 0 Extrapolate, extrapolation interval = *Extrapolate*
< 0 Extrapolate, extrapolation interval = *Extrapolate* * (LRmax – LRmin)
(LRmax and LRmin are maximum and minimum values in the lookup row, respectively).

The size of extrapolation interval also determines how the missing points will be processed. See *Missing_pts* and *Extrapolate* for details.
Extrapolation can only be done on numeric values, and if *Interpolate* < 0 or *Interpolate* > 2.

Power Optional, any number, default = 1. This is the exponent used for averaging in double parabolic interpolation (*Interpolate* = 5) and double hyperbolic interpolation (*Interpolate* = 6). The weight used for averaging between the left and the right curve is raised to this power. In a special case for *Power* = 0 the averaging weight is calculated using a sine curve.

Missing_pts Optional, TRUE or FALSE, default = FALSE. Determines whether to allow blank and non-numeric cells in the lookup row and return row. It has no effect when *Interpolate* = 0. In that case the table may contain any values.
FALSE blank and non-numeric cells are NOT allowed;
TRUE blank and non-numeric cells are allowed. How the table with missing points (blank and non-numeric cells) will be processed also depends on the extrapolation interval.

Error_msg Optional, TRUE or FALSE, default = FALSE. In case of an error, it determines whether or not to return a detailed text error message indicating the cause of the error instead of a standard Excel error code (such as #NA or #VALUE!).
FALSE return a standard Excel error code;
TRUE return a detailed text error message.

Index_mode Optional, TRUE or FALSE, default = FALSE. It determines the way *Lookup_title* and *Return_title* are used to select the lookup and return rows.
FALSE select the lookup and return rows by the row titles;
TRUE select the rows by the row index numbers (positions in *Table_array*). In this case the row titles in the leftmost column of *Table_array* are ignored.

Remarks

- If you do NOT need to extrapolate, or process tables with blank and non-numeric cells, you can also use the simplified THLKP function. It uses default values for the following parameters:
  Extrapolate = 0 (no extrapolation);
  Power = 1 (linear order curve averaging for *Interpolate* = 5 and *Interpolate* = 6);
  Missing_pts = FALSE (blank and non-numeric cells are NOT allowed).
- Use TVLOOKUP instead of THLOOKUP when your lookup and return values are located in table **columns**.

THLKP

THLKP is a simplified version of THLOOKUP function that uses default parameter values. It identifies lookup row and return row of a 2D multi row table by searching for the specified lookup and return titles in the leftmost column of the table, or by row index numbers; then searches for the specified lookup value in the lookup row and returns a value from the same column of the return row. Depending on an optional parameter, it can calculate the return value by interpolating table values.

Syntax

THLKP (Lookup_value, Table_array, Lookup_title, Return_title, Interpolate, Error_msg, Index_mode)

Lookup_value For *Interpolate* = 0, 1, or 2 it is the numeric or text value to be found in the lookup row; for *Interpolate* < 0 or *Interpolate* > 2 it is a numeric value that is compared to the values in the lookup row and for which an interpolated value from the return row is calculated.

Table_array is the lookup table. It is a single area rectangular range of cells that contains lookup row and return row. The first (leftmost) column contains row titles. *Table_array* must contain a minimum of 2 rows and 2 columns. It can also be a reference to a range name.

Lookup_title For *Index_mode* = FALSE it is the exact value (numeric or text - not case sensitive) to be found in the first (leftmost) column of the lookup table in order to identify the lookup row. THLKP searches this row for the specified lookup value. Any row in the *Table_array* can be specified as the lookup row.

For *Index_mode* = TRUE it specifies the lookup row index number (position of the lookup row in *Table_array*: 1 for the first row, 2 for the second row, etc.).

Return_title For *Index_mode* = FALSE it is the exact value (numeric or text - not case sensitive) to be found in the first (leftmost) column of the lookup table in order to identify the return row. THLKP returns the value from this row, or uses it to calculate the interpolated return value. Any row in the *Table_array* can be specified as the return row.

For *Index_mode* = TRUE it specifies the return row index number (position of the return row in *Table_array*: 1 for the first row, 2 for the second row, etc.).

Interpolate Optional, whole number between -20 and 7 (0 to 4 in TriLookupLite), default = 0. It is the type of interpolation to be used in determining the return value. The following types of interpolation can be used:

0 Exact match only (default);
1 Exact or next lower value;
2 Exact or next higher value;
3 Closest value;
4 Linear interpolation;
5 Double parabolic piecewise curve interpolation;
6 Double hyperbolic piecewise curve interpolation;
7 Cubic spline curve interpolation;
-1 to -20 Polynomial curve interpolation (order n = -*Interpolate*).

For *Interpolate* <> 0, the values in the lookup row must be constantly ascending or descending. For example, the following array of values is invalid: 2, 3, 3, 4.
For *Interpolate* < 0 or *Interpolate* > 2, the values in both lookup row and return row must be numeric.

Error_msg   Optional, TRUE or FALSE, default = FALSE. In case of an error, it determines whether or not to return a detailed text error message indicating the cause of the error instead of a standard Excel error code (such as #NA or #VALUE!).
FALSE   return a standard Excel error code;
TRUE   return a detailed text error message.

Index_mode   Optional, TRUE or FALSE, default = FALSE. It determines the way *Lookup_title* and *Return_title* are used to select the lookup and return rows.
FALSE   select the lookup and return rows by the row titles;
TRUE   select the rows by the row index numbers (positions in *Table_array*). In this case the row titles in the leftmost column of *Table_array* are ignored.

Remarks

- THLKP is a simplified version of the THLOOKUP function. It uses default values for the following parameters:
  Extrapolate = 0 (no extrapolation);
  Power = 1 (linear curve averaging for *Interpolate* = 5 and *Interpolate* = 6);
  Missing_pts = FALSE (blank and non-numeric cells are NOT allowed).
- If you need to extrapolate, or process tables with blank and non-numeric cells, you must use the THLOOKUP function.

T2LOOKUP

Searches a 2D (X-Y) lookup table for horizontal (X) values in topmost row and vertical (Y) values in leftmost column and returns a value V(x,y) from the intersecting row and column. Depending on optional parameters, it can also interpolate and extrapolate table values in both horizontal (X) and/or vertical (Y) directions. If desired, it can also process tables with missing or invalid values.

Syntax

T2LOOKUP (**X_value**, **Y_value**, **Table_XY**, X_interpolate, Y_interpolate, X_extrapolate, Y_extrapolate, X_power, Y_power, Do_Y_1st, Missing_pts, Error_msg)

X_value is X-axis lookup value. For *X_interpolate* = 0, 1, or 2 it is the numeric or text value to be found in the X-axis (topmost row of *Table_XY*). For *X_interpolate* < 0 or *X_interpolate* > 2 it is a numeric value to be found in the X-axis. If no exact match is found, T2LOOKUP performs interpolation (or optional extrapolation) in the horizontal (X) direction.

Y_value is Y-axis lookup value. For *Y_interpolate* = 0, 1, or 2 it is the numeric or text value to be found in the Y-axis (leftmost column of *Table_XY*). For *Y_interpolate* < 0 or *Y_interpolate* > 2 it is a numeric value to be found in the Y-axis. If no exact match is found, T2LOOKUP performs interpolation (or optional extrapolation) in the vertical (Y) direction.

Table_XY is the lookup table. It is a single area 2D rectangular range of cells that contains X-axis in the topmost row and Y-axis in the leftmost column, with the top-left cell being ignored. The remainder of *Table_XY* contains data area with return values for each X-Y point. *Table_XY* must have a minimum of 2 rows and 2 columns. It can also be a reference to a range name.

X_interpolate and Y_interpolate Optional, whole number between -20 and 7 (0 to 4 in TriLookupLite), default = 0. The types of interpolation to be used in the horizontal (X) and vertical (Y) directions respectively, when determining the return value. Any of the following types of interpolation can be used independently for each axis:

0 Exact match only (default);
1 Exact or next lower value;
2 Exact or next higher value;
3 Closest value;
4 Linear interpolation;
5 Double parabolic piecewise curve interpolation;
6 Double hyperbolic piecewise curve interpolation;
7 Cubic spline curve interpolation;
-1 to -20 Polynomial curve interpolation (order n = -*Interpolate*).

For *X/Y_interpolate* <> 0, the values in the corresponding axis must be constantly ascending or descending. For example, the following array of values is invalid: 2, 3, 3, 4.
For *X/Y_interpolate* < 0 or *X/Y_interpolate* > 2, the corresponding axis and all return values must be numeric.

X_extrapolate and Y_extrapolate Optional, any number, default = 0 (no extrapolation). Determines whether to perform extrapolation in the horizontal (X) and vertical (Y)

directions respectively, and the sizes of extrapolation intervals (how far to extrapolate past the minimum and maximum values in X-axis and Y-axis). The following values can be used:
0 Do not extrapolate;
> 0 Extrapolate along X/Y axis, X/Y extrapolation interval = *X/Y_extrapolate*
< 0 Extrapolate along X/Y axis, X/Y extrapolation interval = *X/Y_extrapolate* * (Amax – Amin)
(Amax and Amin are maximum and minimum values in the corresponding axis).

The sizes of extrapolation intervals also determine how the missing points will be processed. See *Missing_pts* and *Extrapolate* for details.
Extrapolation can only be done on numeric values, for *X/Y_interpolate* < 0 or *X/Y_interpolate* > 2.

X_power and Y_power Optional, any number, default = 1. These are the exponents used for averaging in double parabolic interpolation (*Interpolate* = 5) and double hyperbolic interpolation (*Interpolate* = 6) in the horizontal (X) and vertical (Y) directions, respectively. The weight used for averaging between the left and the right curve is raised to this power. In a special case for *Power* = 0 the averaging weight is calculated using a sine curve.

Do_Y_1st Optional, TRUE or FALSE, default = FALSE. Determines the order in which interpolations along X-axis and Y-axis are performed, when both are required.
FALSE first perform interpolation along X-axis for the given *X_value* within each row of the table. Then perform interpolation along Y-axis for the given *Y_value* using the interpolated values obtained for each row.
TRUE first perform interpolation along Y-axis for the given *Y_value* within each column of the table. Then perform interpolation along X-axis for the given *X_value* using the interpolated values obtained for each column.

If the 3D surface described by the X-Y lookup table is reasonably smooth and there are few missing points, then the values returned by T2LOOKUP will not change significantly when you alter the order of interpolation.

Missing_pts Optional, TRUE or FALSE, default = FALSE. Determines whether to allow blank and non-numeric cells in *Table_XY*. It has no effect when both *X_interpolate* = 0 and *Y_interpolate* = 0. In that case the table may contain any values.
FALSE blank and non-numeric cells are NOT allowed;
TRUE blank and non-numeric cells are allowed. How the table with missing points (blank and non-numeric cells) will be processed also depends on the X and Y extrapolation intervals.

Error_msg Optional, TRUE or FALSE, default = FALSE. In case of an error, it determines whether or not to return a detailed text error message indicating the cause of the error instead of a standard Excel error code (such as #NA or #VALUE!).
FALSE return a standard Excel error code;
TRUE return a detailed text error message.

Remarks

- If you do NOT need to extrapolate, or process tables with blank and non-numeric cells, or use different types of interpolation along X and Y axes, you can also use the simplified T2LKP function. It uses the same value of the *Interpolate* parameter for both

X and Y axes. It also uses default values for the following parameters:
X/Y_extrapolate = 0 (no extrapolation);
X/Y_power = 1 (linear curve averaging for *Interpolate* = 5 and *Interpolate* = 6);
Do_Y_1st = FALSE (First interpolate along X-axis, for *X_value*, then along Y-axis);
Missing_pts = FALSE (blank and non-numeric cells are NOT allowed).

T2LKP

T2LKP is a simplified version of T2LOOKUP that uses default parameter values. It searches a 2D (X-Y) lookup table for horizontal (X) values in topmost row and vertical (Y) values in leftmost column and returns a value V(x,y) from the intersecting row and column. Depending on an optional parameter, it can interpolate table values in both horizontal (X) and vertical (Y) directions.

Syntax

T2LKP (**X_value**, **Y_value**, **Table_XY**, Interpolate, Error_msg)

X_value is X-axis lookup value. For *Interpolate* = 0, 1, or 2 it is the numeric or text value to be found in the X-axis (topmost row of *Table_XY*). For *Interpolate* < 0 or *Interpolate* > 2 it is a numeric value to be found in the X-axis. If no exact match is found, T2LKP performs interpolation in the horizontal (X) direction.

Y_value is Y-axis lookup value. For *Interpolate* = 0, 1, or 2 it is the numeric or text value to be found in the Y-axis (leftmost column of *Table_XY*). For *Interpolate* < 0 or *Interpolate* > 2 it is a numeric value to be found in the Y-axis. If no exact match is found, T2LKP performs interpolation in the vertical (Y) direction.

Table_XY is the lookup table. It is a single area 2D rectangular range of cells that contains X-axis in the topmost row and Y-axis in the leftmost column, with the top-left cell being ignored. The remainder of *Table_XY* contains data area with return values for each X-Y point. *Table_XY* must have a minimum of 2 rows and 2 columns. It can also be a reference to a range name.

Interpolate Optional, whole number between -20 and 7 (0 to 4 in TriLookupLite), default = 0. The type of interpolation to be used in both horizontal (X) and vertical (Y) directions when determining the return value. Any of the following types of interpolation can be used:

0 Exact match only (default);
1 Exact or next lower value;
2 Exact or next higher value;
3 Closest value;
4 Linear interpolation;
5 Double parabolic piecewise curve interpolation;
6 Double hyperbolic piecewise curve interpolation;
7 Cubic spline curve interpolation;
-1 to -20 Polynomial curve interpolation (order n = -*Interpolate*).

For *Interpolate* <> 0, the values in both axes must be constantly ascending or descending. For example, the following array of values is invalid: 2, 3, 3, 4.
For *Interpolate* < 0 or *Interpolate* > 2, the values in the whole 2D lookup table must be numeric.

Error_msg Optional, TRUE or FALSE, default = FALSE. In case of an error, it determines whether or not to return a detailed text error message indicating the cause of the error instead of a standard Excel error code (such as #NA or #VALUE!).
FALSE return a standard Excel error code;
TRUE return a detailed text error message.

Remarks

- T2LKP is a simplified version of the T2LOOKUP function. It uses the same value of the *Interpolate* parameter for both X and Y axes. It also uses default values for the following parameters:
  X/Y_extrapolate = 0 (no extrapolation);
  X/Y_power = 1 (linear curve averaging for *Interpolate* = 5 and *Interpolate* = 6);
  Do_Y_1st = FALSE (First interpolate along X-axis, for *X_value*, then along Y-axis);
  Missing_pts = FALSE (blank and non-numeric cells are NOT allowed).
- If you need to extrapolate, or process tables with blank and non-numeric cells, or use different types of interpolation along X and Y axes, you must use the T2LOOKUP function.

T3LOOKUP

Searches a 3D (X-Y-Z) lookup table for horizontal (X) values in topmost row, vertical (Y) values in leftmost column and table (Z) values in the top left corners of each 2D table that is a part of the 3D lookup table. Returns a value V(x,y,z) from the intersecting row, column and table. Depending on optional parameters, it can interpolate and extrapolate return values in X, Y and Z directions. If desired, it can also process 3D tables with missing or invalid values.

Syntax

T3LOOKUP (**X_value**, **Y_value**, **Z_value**, **Table_XYZ**, Table_Ygap, Table_Ysize, X_interpolate, Y_interpolate, Z_interpolate, X_extrapolate, Y_extrapolate, Z_extrapolate, X_power, Y_power, Z_power, Do_Y_1st, Missing_pts, Error_msg)

X_value is X-axis lookup value. For *X_interpolate* = 0, 1, or 2 it is the numeric or text value to be found in the X-axis (topmost row of the first 2D table of *Table_XYZ*). For *X_interpolate* < 0 or *X_interpolate* > 2 it is a numeric value to be found in the X-axis. If no exact match is found, T3LOOKUP performs interpolation (or optional extrapolation) in the horizontal (X) direction.

Y_value is Y-axis lookup value. For *Y_interpolate* = 0, 1, or 2 it is the numeric or text value to be found in the Y-axis (leftmost column of the first 2D table of *Table_XYZ*). For *Y_interpolate* < 0 or *Y_interpolate* > 2 it is a numeric value to be found in the Y-axis. If no exact match is found, T3LOOKUP performs interpolation (or optional extrapolation) in the vertical (Y) direction.

Z_value is Z-axis lookup value. For *Z_interpolate* = 0, 1, or 2 it is the numeric or text value to be found in the Z-axis (top left corner cells of each 2D table that is a part of the 3D table *Table_XYZ*). For *Z_interpolate* < 0 or *Z_interpolate* > 2 it is a numeric value to be found in the Z-axis. If no exact match is found, T3LOOKUP performs interpolation (or optional extrapolation) in the Z direction (between individual 2D tables that are part of *Table_XYZ)*.

Table_XYZ is the lookup table. It is a 3D table that contains multiple 2D tables, where each 2D table is a rectangular range of cells and where each 2D table corresponds to a different Z-axis value. All component 2D tables must be the same size in horizontal (X) and vertical (Y) direction as the first 2D table. There are two different ways of specifying the 3D lookup table:

- As a **Single Area Table** – All component 2D tables are contained in a single rectangular range of cells, with the first 2D table on top and the subsequent ones below it. In order for the T3LOOKUP function to be able to differentiate between individual 2D tables, you must specify the values for *Table_Ygap*, *Table_Ysize* (see below).
- As a **Multi Area Table** – Each component 2D table is specified as a separate area in a multiple area range of cells, with the first 2D table specified as the first area of the range, and the subsequent ones listed after it. If *Table_XYZ* refers to a multiple area range, only the top-left cells need to be specified for the subsequent 2D tables.
  If you use a multiple area table, T3LOOKUP will ignore the values for

Table_Ygap, *Table_Ysize*.
Note that all component 2D tables must be located on a same worksheet.

The first 2D table contains X-axis in its topmost row and Y-axis in its leftmost column. In the remaining 2D tables the topmost rows and the leftmost columns are ignored. The Z-axis cells are located in the top left corner cells of each component 2D table. The remainder of the 2D tables (excluding topmost rows and leftmost columns) contain data areas with return values for each X-Y-Z point.

The component 2D tables in *Table_XYZ* must contain a minimum of 2 rows and 2 columns. The number of 2D tables in *Table_XYZ* must be between 1 and 255. *Table_XYZ* can also be a reference to a range name.

Table_Ygap Optional, whole number between 0 and 255, default = 0. It is only used when *Table_XYZ* refers to a **single area table**, to determine the number of rows separating component 2D tables. For example, if *Table_Ygap* = 2, then two rows above each component 2D table (including the first 2D table) are ignored. The value of this parameter is ignored if *Table_XYZ* refers to a Multi Area Table.

Table_Ysize Optional, whole number between 2 and 32767. It is used only when *Table_XYZ* refers to a **single area table**, to determine the number of rows in each component 2D table, excluding the separator rows. If omitted, it is assumed to be equal to the total number of rows in *Table_XYZ* minus the value for *Table_Ygap* (i.e. it is assumed that *Table_XYZ* contains only one 2D table). The value of this parameter is ignored if *Table_XYZ* refers to a Multi Area Table.

X_interpolate, Y_interpolate and Z_interpolate Optional, whole number between -20 and 7 (0 to 4 in TriLookupLite), default = 0. The types of interpolation to be used in the horizontal (X) and vertical (Y) directions and between component 2D tables (Z direction), respectively, when determining the return value. Any of the following types of interpolation can be used independently for each axis:
0 Exact match only (default);
1 Exact or next lower value;
2 Exact or next higher value;
3 Closest value;
4 Linear interpolation;
5 Double parabolic piecewise curve interpolation;
6 Double hyperbolic piecewise curve interpolation;
7 Cubic spline curve interpolation;
-1 to -20 Polynomial curve interpolation (order n = -*Interpolate*).

For *X/Y/Z_interpolate* <> 0, the values in the corresponding axis must be constantly ascending or descending. For example, the following array of values is invalid: 2, 3, 3, 4.
For *X/Y/Z_interpolate* < 0 or *X/Y/Z_interpolate* > 2, the corresponding axis and all return values must be numeric.

X_extrapolate, Y_extrapolate and Z_extrapolate Optional, any number, default = 0 (no extrapolation). Determines whether to perform extrapolation in the horizontal (X) and vertical (Y) directions and between component 2D tables (Z direction), respectively, and the sizes of extrapolation intervals (how far to extrapolate past the minimum and maximum values in X-axis, Y-axis and Z-axis).
0 Do not extrapolate;

> 0 Extrapolate, extrapolation interval = *Extrapolate*
< 0 Extrapolate, extrapolation interval = *Extrapolate* * (Amax – Amin)
(Amax and Amin are maximum and minimum values in the corresponding axis).

The sizes of extrapolation intervals also determine how the missing points will be processed. See *Missing_pts* and *Extrapolate* for details.
Extrapolation can only be done on numeric values, for *X/Y_interpolate* < 0 or *X/Y_interpolate* > 2.

X_power, Y_power and Z_power Optional, any number, default = 1. These are the exponents used for averaging in double parabolic interpolation (*Interpolate* = 5) and double hyperbolic interpolation (*Interpolate* = 6) in the horizontal (X) and vertical (Y) directions and between 2D tables (Z direction), respectively. The weight used for averaging between the left and the right curve is raised to this power. In a special case for *Power* = 0 the averaging weight is calculated using a sine curve.

Do_Y_1st Optional, TRUE or FALSE, default = FALSE. Determines the order in which interpolations for *X_value* and *Y_value* are performed, when both are required. Note that the interpolation along Z-axis (between the 2D component tables), if required, is always performed last.
FALSE first perform interpolation along X-axis for the given *X_value* within each row of each 2D component table. Then perform interpolation along Y-axis for the given *Y_value* using the interpolated values obtained for each row in each 2D table.
TRUE first perform interpolation along Y-axis for the given *Y_value* within each column of each 2D component table. Then perform interpolation along X-axis for the given *X_value* using the interpolated values obtained for each column in each 2D table.

If the 3D surfaces described by the component 2D tables are reasonably smooth and with few missing points, then the values returned by T3LOOKUP will not change significantly when you alter the order of X and Y interpolation.

Missing_pts Optional, TRUE or FALSE, default = FALSE. Determines whether to allow blank and non-numeric cells in *Table_XYZ*. It has no effect when *X_interpolate*, *Y_interpolate* and *Z_interpolate* all equal 0. In that case the table may contain any values.
FALSE blank and non-numeric cells are NOT allowed;
TRUE blank and non-numeric cells are allowed. How the table with missing points (blank and non-numeric cells) will be processed also depends on the X, Y and Z extrapolation intervals.

Error_msg Optional, TRUE or FALSE, default = FALSE. In case of an error, it determines whether or not to return a detailed text error message indicating the cause of the error instead of a standard Excel error code (such as #NA or #VALUE!).
FALSE return a standard Excel error code;
TRUE return a detailed text error message.

Remarks

- If you do NOT need to extrapolate, or process tables with blank and non-numeric cells, or use different types of interpolation along X, Y and Z axes, you can also use the simplified T3LKP function. It uses the same value of the *Interpolate* parameter for all three axes and can only process **Multi Area Tables**. It also uses default values for the

following parameters:
Table_Ygap and Table_Ysize (not used for a multi area 3D table);
X/Y/Z_extrapolate = 0 (no extrapolation);
X/Y/Z_power = 1 (linear curve averaging for *Interpolate* = 5 and *Interpolate* = 6);
Do_Y_1st = FALSE (first interpolate along X-axis, then along Y-axis and finally along Z-axis);
Missing_pts = FALSE (blank and non-numeric cells are NOT allowed).

T3LKP

T3LKP is a simplified version of T3LOOKUP that uses default parameter values. It searches a 3D (X-Y-Z) lookup table for horizontal (X) values in topmost row, vertical (Y) values in leftmost column and table (Z) values in the top left corners of each 2D table that is a part of the 3D lookup table. Returns a value V(x,y,z) from the intersecting row, column and table. Depending on an optional parameter, it can interpolate return values in X, Y and Z directions.

Syntax

T3LKP (X_value, Y_value, Z_value, Table_XYZ, Interpolate, Error_msg)

X_value is X-axis lookup value. For *Interpolate* = 0, 1, or 2 it is the numeric or text value to be found in the X-axis (topmost row of the first 2D table of *Table_XYZ*). For *Interpolate* < 0 or *X_interpolate* > 2 it is a numeric value to be found in the X-axis. If no exact match is found, T3LKP performs interpolation in the horizontal (X) direction.

Y_value is Y-axis lookup value. For *Interpolate* = 0, 1, or 2 it is the numeric or text value to be found in the Y-axis (leftmost column of the first 2D table of *Table_XYZ*). For *Interpolate* < 0 or *Interpolate* > 2 it is a numeric value to be found in the Y-axis. If no exact match is found, T3LKP performs interpolation in the vertical (Y) direction.

Z_value is Z-axis lookup value. For *Interpolate* = 0, 1, or 2 it is the numeric or text value to be found in the Z-axis (top left corner cells of each 2D table that is a part of the 3D table *Table_XYZ*). For *Interpolate* < 0 or *Interpolate* > 2 it is a numeric value to be found in the Z-axis. If no exact match is found, T3LKP performs interpolation in the Z direction (between individual 2D tables that are part of *Table_XYZ)*.

Table_XYZ is the lookup table. It is a 3D table that contains multiple 2D tables, where each 2D table is a rectangular ranges of cells and where each 2D table corresponds to a different Z-axis value. All component 2D tables must be the same size in horizontal (X) and vertical (Y) direction as the first 2D table.

T3LKP can only use **Multi Area Tables**, where each component 2D table is specified as a separate area in a multiple area range of cells. The first 2D table is specified as the first area of the range and the subsequent ones are listed after it. Note that only the top-left cells need to be specified for the subsequent 2D tables.

Note that all component 2D tables must be located on a same worksheet.

The first 2D table contains X-axis in its topmost row and Y-axis in its leftmost column. In the remaining 2D tables the topmost rows and the leftmost columns are ignored. The Z-axis cells are located in the top left corner cells of each component 2D table. The remainder of the 2D tables (excluding topmost rows and leftmost columns) contain data areas with return values for each X-Y-Z point.

The component 2D tables in *Table_XYZ* must contain a minimum of 2 rows and 2 columns. The number of 2D tables in *Table_XYZ* must be between 1 and 255. *Table_XYZ* can also be a reference to a range name.

Interpolate Optional, whole number between -20 and 7 (0 to 4 in TriLookupLite), default = 0. The type of interpolation to be used in all three directions (X, Y and Z) when determining the return value. Any of the following types of interpolation can be used:

0 Exact match only (default);
1 Exact or next lower value;
2 Exact or next higher value;
3 Closest value;
4 Linear interpolation;
5 Double parabolic piecewise curve interpolation;
6 Double hyperbolic piecewise curve interpolation;
7 Cubic spline curve interpolation;
-1 to -20 Polynomial curve interpolation (order n = -*Interpolate*).

For *Interpolate* <> 0, the values in all axes must be constantly ascending or descending. For example, the following array of values is invalid: 2, 3, 3, 4.
For *Interpolate* < 0 or *Interpolate* > 2, the values in the whole 3D lookup table must be numeric.

Error_msg Optional, TRUE or FALSE, default = FALSE. In case of an error, it determines whether or not to return a detailed text error message indicating the cause of the error instead of a standard Excel error code (such as #NA or #VALUE!).
FALSE return a standard Excel error code;
TRUE return a detailed text error message.

Remarks

- T3LKP is a simplified version of the T3LOOKUP function. It uses the same value of the *Interpolate* parameter for all three axes and can only process **Multi Area Tables**. It also uses default values for the following parameters:
  Table_Ygap and Table_Ysize (not used for a multi area 3D table);
  X/Y/Z_extrapolate = 0 (no extrapolation);
  X/Y/Z_power = 1 (linear curve averaging for *Interpolate* = 5 and *Interpolate* = 6);
  Do_Y_1st = FALSE (first interpolate along X-axis, then along Y-axis and finally along Z-axis);
  Missing_pts = FALSE (blank and non-numeric cells are NOT allowed).
- If you need to extrapolate, or process tables with blank and non-numeric cells, or use different types of interpolation along X, Y and Z axes, or wish to specify a Single Area 3D Table, you must use the T3LOOKUP function.

TVPOLYDATA

Identifies lookup (X) and return (Y) columns of a 2D multi column table by searching for the specified lookup and return titles in the topmost row of the table, or by column index numbers; then calculates polynomial curve coefficients up to a specified order (maximum order = 20). The polynomial curves are fitted using the least squares method through the X-Y data points given in the lookup column and return column of the table. You can assign any column of the table as the lookup (X) column and return (Y) column by simply specifying the column titles. The function also determines the best fit curve (the one with the maximum value of R^2).

Syntax

TVPOLYDATA (**Table_array**, **Lookup_title**, **Return_title**, **Max_order**, Smooth_R2, Normalized, Missing_pts, Error_msg, Index_mode)

Table_array is the lookup table. It is a single area rectangular range of cells that contains lookup (X) and return (Y) columns. The first (topmost) row contains column titles. *Table_array* must contain a minimum of 2 rows and 2 columns. It can also be a reference to a range name.

Lookup_title For *Index_mode* = FALSE it is the exact value (numeric or text - not case sensitive) to be found in the first (topmost) row of the table in order to identify the lookup column. TVPOLYDATA uses the values in this column as the X (independent variable) coordinates of the set of points through which to fit the polynomial curves. Any column in the *Table_array* can be specified as the lookup column.

For *Index_mode* = TRUE it specifies the lookup column index number (position of the lookup column in *Table_array*: 1 for the first column, 2 for the second column, etc.).

Return_title For *Index_mode* = FALSE it is the exact value (numeric or text - not case sensitive) to be found in the first (topmost) row of the table in order to identify the return column. TVPOLYDATA uses the values in this column as the Y (dependant variable) coordinates of the set of points through which to fit the polynomial curves. Any column in the *Table_array* can be specified as the return column.

For *Index_mode* = TRUE it specifies the return column index number (position of the return column in *Table_array*: 1 for the first column, 2 for the second column, etc.).

Max_order is the maximum order **n** for which the polynomial curves should be calculated. The valid values are 1 to 20 (1 to 6 in TriLookupLite). TVPOLYDATA calculates the coefficients for every polynomial curve with the order between 1 and the maximum order. In case the maximum order **n** equals or exceeds the number of valid X-Y points in the lookup table (p), TVPOLYDATA automatically reduces it to one less than the number of points (n = p - 1).

Smooth_R2 Optional, TRUE or FALSE, default = FALSE. When set to TRUE, TVPOLYDATA uses additional in-between points when calculating the R-squared value (R^2) and the sum of error squares (residuals) of the polynomial curve (Sum(E^2)). The *Smooth_R2* parameter also affects which curve will be picked as the best fit curve – the one with the highest R^2 and lowest Sum(E^2).

Normalized   Optional, TRUE or FALSE, default = FALSE. When set to TRUE, TVPOLYDATA first performs a linear transformation (mapping) of the original lookup (X) values into X' values which lie in the -1 to +1 range. This can help reduce the calculation errors (caused by the limits in precision of the 32 bit floating point computations) in some cases where the polynomial order **n** is high (for example n > 15). When using the polynomial coefficients returned by TVPOLYDATA with *Normalized* = TRUE, you must first transform the X values into X' using the Ax and Bx coefficients (also returned by TVPOLYDATA) in the following way: X' = Ax•X + Bx.

Missing_pts   Optional, TRUE or FALSE, default = FALSE. Determines whether to allow blank and non-numeric cells in the lookup column and return column.
FALSE   blank and non-numeric cells are NOT allowed;
TRUE   blank and non-numeric cells are ignored.

Error_msg   Optional, TRUE or FALSE, default = FALSE. In case of an error, it determines whether or not to return a detailed text error message indicating the cause of the error instead of a standard Excel error code (such as #NA or #VALUE!).
FALSE   return a standard Excel error code;
TRUE   return a detailed text error message.

Index_mode   Optional, TRUE or FALSE, default = FALSE. It determines the way *Lookup_title* and *Return_title* are used to select the lookup and return columns.
FALSE   select the lookup and return columns by the column titles;
TRUE   select the columns by the column index numbers (positions in *Table_array*). In this case the column titles in the topmost row of *Table_array* are ignored.

QR_mode   Optional, TRUE or FALSE, default = FALSE. It determines the method TriLookup will use to solve the system of least squares linear equations.
FALSE   TriLookup will solve the least squares equations using Excel's internal MINV function.
TRUE   TriLookup will solve the least squares equations using Householder QR decomposition method. This method is slower, but more accurate, compared to Excel's built-in MINV function and can be should to improve the accuracy of calculation when Max_order is 10 or higher. For more details on QR decomposition method see https://en.wikipedia.org/wiki/QR_decomposition.

Remarks

- TVPOLYDATA returns an array of up to 22 rows by 26 columns. The size depends on the maximum polynomial order used: the number of rows equals *Max_order* + 2 and the number of columns equals *Max_order* + 6. Although you do not have use an array formula, it greatly speeds up the calculation. For more information on array formulas see Excel's Array Formulas help topic.
- In order to help interpret the values returned by the array formula, the topmost row of the array returned by TVPOLYDATA contains column titles as follows:

  Order   is the order of the polynomial curve.

  R^2 is the R-squared value. It is an indication of how close the polynomial curve fits the data points. Its value can be between 0 and 1, with $R^2 = 1$ indicating the perfect fit. TVPOLYDATA calculates R^2 from the following formula:

$$R^2 = 1 - \frac{\sum \left(Y_i - \hat{Y}_i\right)^2}{\left(\sum Y_i^2\right) - \frac{\left(\sum Y_i\right)^2}{p}}$$

where Y_i are given values and $\hat{Y}_i$ are values on the polynomial curve, and p is the number of points.

Note that R^2 returned by TVPOLYDATA is the same R-squared value as the one displayed by Excel for polynomial trendlines and the one returned by Excel's RSQ function.

If you specify *Smooth_R2* = TRUE, then R^2 is calculated for the extra in-between points, in addition to the points given in the table. For more details see *Smooth_R2*.

Sum(E^2) is the sum of error squares (residuals) of a polynomial curve. It is another indication of how close the polynomial curve fits the data points. It is calculated from the following formula:

$$\sum E^2 = \sum \left(Y_i - \hat{Y}_i\right)^2$$

Lower values of Sum(E^2) indicate a better fit. In case of a perfect fit Sum(E^2) = 0, which corresponds to $R^2 = 1$. If you specify *Smooth_R2* = TRUE, then Sum(E^2) is calculated for the extra in-between points, in addition to the points given in the table. For more details see *Smooth_R2*.

Ax, **Bx** are the coefficients used to normalize (transform) the table X values into X' values which lie in the -1 to +1 range (X' = Ax•X + Bx) when *Normalized* = TRUE option is used. If the default *Normalized* = FALSE is used, then the "Ax" and "Bx" columns are replaced by "TPOLY(...)" and "Formula" (see below).

TPOLY(...) is a ready-made formula string that uses the TPOLY function to calculate the value of the polynomial curve, for example, "TPOLY(X,4,{-3.12,-1.97,0.172,-4.86E-03,4.41E-05})" is a TPOLY formula string for a 4th order polynomial. In order to use the formula, you must first Copy the value of the TPOLY(...) cell into the clipboard and then use Paste Special | Values to paste it into another cell. After that, you should add the "=" sign to the beginning of the formula and replace all "X" characters with valid references to the X value. Note that TPOLY(...) is returned only for *Normalized* = FALSE, otherwise the column is used to return the Ax value (see above).

Due to Excel's limitation on the length of strings that can be returned as a part of an array formula, if the length of the formula string exceeds 255 characters, TVPOLYDATA will return #N/A instead. For this reason, the maximum order for which the TPOLY formula string is returned is n = 11.

Formula is a ready-made inline formula string that can be used to calculate the value of the polynomial curve, for example, "-15.97+1.109*X-2.091E-02*X^2+1.321-04*X^3" is an inline formula string for a 3rd order polynomial. In order to use the formula, you must first Copy the value of the Formula cell into the clipboard and then use Paste Special | Values to paste it into another cell. After that, you should add the "=" sign to the beginning of the formula and replace all "X" characters with valid references to the X value. Note that Formula is returned only for *Normalized* = FALSE, otherwise the column is used to return the Bx value (see above).

Due to Excel's limitation on the length of strings that can be returned as a part of an array formula, if the length of the formula string exceeds 255 characters, TVPOLYDATA will return #N/A instead. For this reason, the maximum order for which the inline formula string is returned is n = 10.

c0, c1, c2, c3...c20 are the polynomial curve coefficients returned by TVPOLYDATA. The polynomial curve is defined as $Y = c_0 + c_1 \cdot X + c_2 \cdot X^2 + c_3 \cdot X^3 + ... + c_n \cdot X^n$; where n is the polynomial order. If the order **n** is less than 20, all coefficients for exponents higher than **n** are returned as zeros.

- The second row of the array returned by TVPOLYDATA (the first one below the title row) contains data for the polynomial curve with the highest R^2 (**the best fit curve**). That way, if is easy to reference the coefficients of the best fit curve without a need to search for the curve with the highest R^2 value.
- TVPOLYDATA picks the best fit curve among the polynomial curves with order between 1 and **n** (the maximum order). Therefore, the order of the best fit curve is always equal to or less than the *Max_order* parameter. You must be careful to specify a high enough value for *Max_order* in order to determine the true best fit curve.
- Use THPOLYDATA instead of TVPOLYDATA when your lookup (X) and return (Y) values are located in table **rows**.

THPOLYDATA

Identifies lookup (X) and return (Y) rows of a 2D multi row table by searching for the specified lookup and return titles in the leftmost column of the table, or by row index numbers; then calculates polynomial curve coefficients up to a specified order (maximum order = 20). The polynomial curves are fitted using the least squares method through the X-Y data points given in the lookup row and return row of the table. You can assign any row of the table as the lookup (X) row and return (Y) row by simply specifying the row titles. The function also determines the best fit curve (the one with the maximum value of R^2).

Syntax

THPOLYDATA (**Table_array**, **Lookup_title**, **Return_title**, **Max_order**, Smooth_R2, Normalized, Missing_pts, Error_msg, Index_mode)

Table_array is the lookup table. It is a single area rectangular range of cells that contains lookup (X) and return (Y) rows. The first (leftmost) column contains row titles. *Table_array* must contain a minimum of 2 rows and 2 columns. It can also be a reference to a range name.

Lookup_title For *Index_mode* = FALSE it is the exact value (numeric or text - not case sensitive) to be found in the first (leftmost) column of the table in order to identify the lookup row. THPOLYDATA uses the values in this row as the X (independent variable) coordinates of the set of points through which to fit the polynomial curves. Any row in the *Table_array* can be specified as the lookup row.

For *Index_mode* = TRUE it specifies the lookup row index number (position of the lookup row in *Table_array*: 1 for the first row, 2 for the second row, etc.).

Return_title For *Index_mode* = FALSE it is the exact value (numeric or text - not case sensitive) to be found in the first (leftmost) column of the table in order to identify the return row. THPOLYDATA uses the values in this row as the Y (dependant variable) coordinates of the set of points through which to fit the polynomial curves. Any row in the *Table_array* can be specified as the return row.

For *Index_mode* = TRUE it specifies the return row index number (position of the return row in *Table_array*: 1 for the first row, 2 for the second row, etc.).

Max_order is the maximum order **n** for which the polynomial curves should be calculated. The valid values are 1 to 20 (1 to 6 in TriLookupLite). THPOLYDATA calculates the coefficients for every polynomial curve with the order between 1 and the maximum order. In case the maximum order **n** equals or exceeds the number of valid X-Y points in the lookup table (p), THPOLYDATA automatically reduces it to one less than the number of points (n = p - 1).

Smooth_R2 Optional, TRUE or FALSE, default = FALSE. When set to TRUE, THPOLYDATA uses additional in-between points when calculating the R-squared value (R^2) and the sum of error squares (residuals) of the polynomial curve (Sum(E^2)). The *Smooth_R2* parameter also affects which curve will be picked as the best fit curve – the one with the highest R^2 and lowest Sum(E^2).

Normalized Optional, TRUE or FALSE, default = FALSE. When set to TRUE, THPOLYDATA first performs a linear transformation (mapping) of the original lookup (X) values into X' values which lie in the -1 to +1 range. This can help reduce the calculation errors (caused by the limits in precision of the 32 bit floating point computations) in some cases where the polynomial order **n** is high (for example n > 15). When using the polynomial coefficients returned by THPOLYDATA with *Normalized* = TRUE, you must first transform the X values into X' using the Ax and Bx coefficients (also returned by THPOLYDATA) in the following way: X' = Ax•X + Bx.

Missing_pts Optional, TRUE or FALSE, default = FALSE. Determines whether to allow blank and non-numeric cells in the lookup row and return row.
FALSE blank and non-numeric cells are NOT allowed;
TRUE blank and non-numeric cells are ignored.

Error_msg Optional, TRUE or FALSE, default = FALSE. In case of an error, it determines whether or not to return a detailed text error message indicating the cause of the error instead of a standard Excel error code (such as #NA or #VALUE!).
FALSE return a standard Excel error code;
TRUE return a detailed text error message.

Index_mode Optional, TRUE or FALSE, default = FALSE. It determines the way *Lookup_title* and *Return_title* are used to select the lookup and return rows.
FALSE select the lookup and return rows by the row titles;
TRUE select the rows by the row index numbers (positions in *Table_array*). In this case the row titles in the leftmost column of *Table_array* are ignored.

QR_mode Optional, TRUE or FALSE, default = FALSE. It determines the method TriLookup will use to solve the system of least squares linear equations.
FALSE TriLookup will solve the least squares equations using Excel's internal MINV function.
TRUE TriLookup will solve the least squares equations using Householder QR decomposition method. This method is slower, but more accurate, compared to Excel's built-in MINV function and can be should to improve the accuracy of calculation when Max_order is 10 or higher. For more details on QR decomposition method see https://en.wikipedia.org/wiki/QR_decomposition.

Remarks

- THPOLYDATA returns an array of up to 22 rows by 26 columns. The size depends on the maximum polynomial order used: the number of rows equals *Max_order* + 2 and the number of columns equals *Max_order* + 6. Although you do not have use an array formula, it greatly speeds up the calculation. For more information on array formulas see Excel's Array Formulas help topic.
- In order to help interpret the values returned by the array formula, the topmost row of the array returned by THPOLYDATA contains column titles as follows:

  Order is the order of the polynomial curve.

  R^2 is the R-squared value. It is an indication of how close the polynomial curve fits the data points. Its value can be between 0 and 1, with $R^2 = 1$ indicating the perfect fit. THPOLYDATA calculates R^2 from the following formula:

$$R^2 = 1 - \frac{\sum \left(Y_i - \hat{Y}_i\right)^2}{\left(\sum Y_i^2\right) - \frac{\left(\sum Y_i\right)^2}{p}}$$

where Y_i are given values and $\hat{Y}_i$ are values on the polynomial curve, and p is the number of points.

Note that R^2 returned by THPOLYDATA is the same R-squared value as the one displayed by Excel for polynomial trendlines and the one returned by Excel's RSQ function.

If you specify *Smooth_R2* = TRUE, then R^2 is calculated for the extra in-between points, in addition to the points given in the table. For more details see *Smooth_R2*.

Sum(E^2) is the sum of error squares (residuals) of a polynomial curve. It is another indication of how close the polynomial curve fits the data points. It is calculated from the following formula:

$$\sum E^2 = \sum \left(Y_i - \hat{Y}_i\right)^2$$

Lower values of Sum(E^2) indicate a better fit. In case of a perfect fit Sum(E^2) = 0, which corresponds to $R^2 = 1$. If you specify *Smooth_R2* = TRUE, then Sum(E^2) is calculated for the extra in-between points, in addition to the points given in the table. For more details see *Smooth_R2*.

Ax, Bx are the coefficients used to normalize (transform) the table X values into X' values which lie in the -1 to +1 range (X' = Ax•X + Bx) when *Normalized* = TRUE option is used. If the default *Normalized* = FALSE is used, then the "Ax" and "Bx" columns are replaced by "TPOLY(...)" and "Formula" (see below).

TPOLY(...) is a ready-made formula string that uses the TPOLY function to calculate the value of the polynomial curve, for example, "TPOLY(X,4,{-3.12,-1.97,0.172,-4.86E-03,4.41E-05})" is a TPOLY formula string for a 4th order polynomial. In order to use the formula, you must first Copy the value of the TPOLY(...) cell into the clipboard and then use Paste Special | Values to paste it into another cell. After that, you should add the "=" sign to the beginning of the formula and replace all "X" characters with valid references to the X value. Note that TPOLY(...) is returned only for *Normalized* = FALSE, otherwise the column is used to return the Ax value (see above).

Due to Excel's limitation on the length of strings that can be returned as a part of an array formula, if the length of the formula string exceeds 255 characters, THPOLYDATA will return #N/A instead. For this reason, the maximum order for which the TPOLY formula string is returned is n = 11.

Formula is a ready-made inline formula string that can be used to calculate the value of the polynomial curve, for example, "-15.97+1.109*X-2.091E-02*X^2+1.321-04*X^3" is an inline formula string for a 3rd order polynomial. In order to use the formula, you must first Copy the value of the Formula cell into the clipboard and then use Paste Special | Values to paste it into another cell. After that, you should add the "=" sign to the beginning of the formula and replace all "X" characters with valid references to the X value. Note that Formula is returned only for *Normalized* = FALSE, otherwise the column is used to return the Bx value (see above).

Due to Excel's limitation on the length of strings that can be returned as a part of an array formula, if the length of the formula string exceeds 255 characters, THPOLYDATA will return #N/A instead. For this reason, the maximum order for which the inline formula string is returned is n = 10.

c0, c1, c2, c3...c20 are the polynomial curve coefficients returned by THPOLYDATA. The polynomial curve is defined as $Y = c_0 + c_1 \cdot X + c_2 \cdot X^2 + c_3 \cdot X^3 + ... + c_n \cdot X^n$; where n is the polynomial order. If the order **n** is less than 20, all coefficients for exponents higher than **n** are returned as zeros.

- The second row of the array returned by THPOLYDATA (the first one below the title row) contains data for the polynomial curve with the highest R^2 (**the best fit curve**). That way, if is easy to reference the coefficients of the best fit curve without a need to search for the curve with the highest R^2 value.
- THPOLYDATA picks the best fit curve among the polynomial curves with order between 1 and **n** (the maximum order). Therefore, the order of the best fit curve is always equal to or less than the *Max_order* parameter. You must be careful to specify a high enough value for *Max_order* in order to determine the true best fit curve.
- Use TVPOLYDATA instead of THPOLYDATA when your lookup (X) and return (Y) values are located in table **columns**.

TPOLY

Returns the Y value of a polynomial curve for a given lookup value (X), polynomial order n and an array of polynomial curve coefficients. It can also be used to calculate any derivative of the polynomial curve.

Syntax

TPOLY (Lookup_value, Order, Coef_array, Derivative)

Lookup_value is a numeric value of the independent (X) variable for which TPOLY will calculate the Y value of the polynomial curve.

Order is the order **n** of the polynomial curve. It must be a whole non-negative number (0, 1, 2, 3...etc). Although there is no upper limit for the *Order*, the practical limit for the 32 bit floating point computation is between 15 and 20.

Coef_array is the array of coefficients of the polynomial curve. The coefficients must be given in the ascending order, starting from c_0 (c_0, c_1, c_2, c_3 .... c_n). *Coef_array* can either be a reference to a single row or a single column range of cells, or it can be specified as an in-line array, such as {3.443,-0.822,0.329,-0.04,0.0011}.

Derivative Optional, a whole non-negative number (0, 1, 2, 3...etc), default = 0. If a non-zero value (**m**) is specified, TPOLY will return the m^{th} derivative (d^mY/dX^m) of the polynomial curve for the X coordinate specified by *Lookup_value*.

Remarks

- The polynomial curve is defined as $Y = c_0 + c_1 \cdot X + c_2 \cdot X^2 + c_3 \cdot X^3 + ... + c_n \cdot X^n$, where c_0, c_1, c_2, c_3 .... c_n are polynomial coefficients and n is the order of the curve.
- In case of an error, such as specifying a negative order or not having enough coefficients in the array for the given order, TPOLY will return Excel's #VALUE! error code. Unlike other TriLookup functions, TPOLY does not offer the option of returning a detailed text error message indicating the cause of the error.

TriLookup Function Parameters

Interpolate Parameter

- Optional parameter, whole number between -20 and 7 (0 to 4 in TriLookupLite), default = 0.
- This parameter determines if and what type of interpolation should be used when calculating the return value.
- The functions with one lookup variable (TVLOOKUP, THLOOKUP, TVLKP and THLKP), use only one *Interpolate* parameter. The T2LOOKUP function, which has 2 lookup (independent) variables (X and Y), and T3LOOKUP with 3 lookup variables (X, Y and Z), have separate interpolation settings for each lookup variable: *X_interpolate*, *Y_interpolate* and, in case of T3LOOKUP, *Z_interpolate*. However, the simplified versions of these functions, T2LKP and T3LKP, respectively, use the same value of *Interpolate* for all lookup variables.
- Note that all references to *Interpolate* below also pertain to *X_interpolate*, *Y_interpolate* and *Z_interpolate*.
- If you use any of the lookup functions to extrapolate beyond the minimum and maximum lookup values (by specifying *Extrapolate* <> 0), the extrapolation will be done by extending the last segment of the interpolation curve. Therefore, the returned extrapolated values will also depend on the value of the *Interpolate* parameter.

Types of interpolation

- *Interpolate* = 0: Exact Match Only
- *Interpolate* = 1: Exact Match or Next Lower Value
- *Interpolate* = 2: Exact Match or Next Higher Value
- *Interpolate* = 3: Closest value
- *Interpolate* = 4: Linear Interpolation
- *Interpolate* = 5: Double Parabolic Piecewise Curve Interpolation
- *Interpolate* = 6: Double Hyperbolic Piecewise Curve Interpolation
- *Interpolate* = 7: Cubic Spline Curve Interpolation
- *Interpolate* = -1 to -20: Polynomial Curve Interpolation

***Interpolate* = 0: Exact Match Only**

- This is the default value for *Interpolate*.
- Works in a way similar to Excel's built-in VLOOKUP and HLOOKUP functions with the *range_*lookup parameter set to FALSE.
- No interpolation is performed. A value is returned only if an exact match can be found for the lookup value in the lookup area. Otherwise, the #N/A error code is returned.
- Lookup and return values can be numeric or text and can be given in any order.

***Interpolate* = 1: Exact Match or Next Lower Value**

- Works in a way similar to Excel's built-in VLOOKUP and HLOOKUP functions with the *range_*lookup parameter set to TRUE.
- No interpolation is performed. A value from the data area corresponding to the largest value that is less than or equal to the lookup value in the lookup area is returned. If the lookup value is smaller than the smallest value in the lookup area, the #N/A error code is returned.
- Lookup and return values can be numeric or text. In addition, the lookup values must be constantly ascending or descending. For example, the following arrays of lookup values are invalid: (2, 3, 3, 4); ("z", "w", "v", "x").

***Interpolate* = 2: Exact Match or Next Higher Value**

- No interpolation is performed. A value from the data area corresponding to the smallest value that is greater than or equal to the lookup value in the lookup area is returned. If the lookup value is greater than the largest value in the lookup area, the #N/A error code is returned.
- Lookup and return values can be numeric or text. In addition, the lookup values must be constantly ascending or descending. For example, the following arrays of lookup values are invalid: (2, 3, 3, 4); ("z", "w", "v", "x").

***Interpolate* = 3: Closest Value**

- Returns the value from the data area that corresponds to the value in the lookup area that is closest to the lookup value.
- All lookup and return values must be numeric. In addition, the lookup values must be constantly ascending or descending. For example, the following array of lookup values is invalid: 2, 3, 3, 4.

***Interpolate* = 4: Linear Interpolation**

- Interpolate using a straight line between the points corresponding to two values in the lookup area that surround the lookup value on each side (one is less than and the other is greater than the lookup value).
- This is the simplest way of interpolating between the table values. Although the curve it produces has sharp corners at each table point, the interpolated values between the points are always predictable, without any "humps" or "dips". When extrapolating past

the minimum and maximum lookup values, linear interpolation is the safest and most predictable method.

- This is also the fastest type of interpolation because it only has to process the values of two table points in order to calculate the interpolated return value. The calculation speed may be important if you are dealing with large 2D or 3D tables and/or have a slow computer.
- All lookup and return values must be numeric. In addition, the lookup values must be constantly ascending or descending. For example, the following array of lookup values is invalid: 2, 3, 3, 4.

Interpolate = 5: Double Parabolic Piecewise Curve Interpolation

- This value of *Interpolate* is not available in TriLookupLite.
- Interpolate by averaging between two smooth parabolic curves (“left” and “right” curve), each drawn through 3 out of 4 points surrounding the lookup value in the lookup area (two on each side of the lookup value).
- The parabolic curve equation is $Y = c_0 + c_1 \cdot X + c_2 \cdot X^2$, where X is the lookup value and Y is the return value.
- This type of interpolation is somewhat slower than linear, but it is significantly faster than spline or polynomial because it only has to process the values of four table points in order to calculate the interpolated return value. The calculation speed may be important if you are dealing with large 2D or 3D tables and/or have a slow computer.
- All lookup and return values must be numeric. In addition, the lookup values must be constantly ascending or descending. For example, the following array of lookup values is invalid: 2, 3, 3, 4.
- The way curve averaging is performed depends on the value of the *Power* parameter.
- If the lookup value lies between the two lowest or the two highest values in the lookup area (i.e. if it is in one of the two end segments), then the interpolation is done along only one parabolic curve drawn through the 3 points surrounding the lookup value.
- The double parabolic piecewise curve used in this type of interpolation always passes through all table points. Its first derivative is continuous throughout the whole curve, while its second derivative generally shows a discontinuity (jump) at each point used to define the curve. The shape of the curve for any lookup value is determined only by the four neighboring points (two at either side).
- If there are only two valid lookup points in the table then the linear interpolation is performed instead.

Interpolate = 6: Double Hyperbolic Piecewise Curve Interpolation

- This value of *Interpolate* is not available in TriLookupLite.
- Interpolate by averaging between two smooth hyperbolic (“left” and “right” curve), each drawn through 3 out of 4 points surrounding the lookup value in the lookup area (two on each side of the lookup value).
- The hyperbolic curve equation is $Y = c_0 + c_1 / (X + c_2)$.

- A three point hyperbolic curve is used if the return values for the 3 adjacent points are constantly increasing or decreasing.
- If the return values for the 3 points are NOT constantly increasing or decreasing, then the value of the middle point is used as a return value in the whole 3-point segment, excluding the end points of the segment, which retain their own value.
- This type of interpolation may not be suited for tables in which the return values are not constantly ascending or descending, especially if a local minimum or maximum is present in either of the end 3-point segments. If a local minimum or maximum is present in any curve segment other than the end segments (such as segment 4,5,6 in the example), the averaging between the left and right curves will smooth out the sudden jumps in return values, producing an acceptable interpolated curve.
- This type of interpolation is somewhat slower than linear, but it is significantly faster than spline or polynomial, because it only has to process the values of four table points in order to calculate the interpolated return value. The calculation speed may be important if you are dealing with large 2D or 3D tables and/or have a slow computer.
- In cases where there are relatively large distances between table points, and the return values are constantly ascending or descending, this type of interpolation usually produces a smoother interpolated curve when compared to all other curvilinear interpolation types. This is because hyperbolic curves do not produce the “humps” and “dips” between the table points. However, when extrapolating past the minimum and maximum lookup values, this type of interpolation can produce unpredictable results.
- All lookup and return values must be numeric. In addition, the lookup values must be constantly ascending or descending. For example, the following array of lookup values is invalid: 2, 3, 3, 4.
- The way curve averaging is performed depends on the value of the *Power* parameter.
- If the lookup point lies between the two lowest or the two highest values in the lookup area (i.e. if it is in one of the two end segments), then the interpolation is done along only one hyperbolic curve (“left” or “right”) drawn through the 3 points surrounding the lookup value.
- The double hyperbolic piecewise curve used in this type of interpolation always passes through all the points. If the return values are constantly increasing or decreasing, its first derivative is continuous throughout the whole curve. The second derivative generally shows a discontinuity (jump) at each point used to define the curve. The shape of the curve at any lookup value is determined only by the four neighboring points (two at either side).
- If there are only two valid lookup points in the table then linear interpolation is performed instead.
- Starting in Version 1.2, the extrapolation for *Interpolate* = 6 is done by extending the tangent drawn through the end point of the hyperbolic curve defined by the end 3-point segment. The extrapolated values now lie on a straight line, which makes the results of extrapolation much more predictable.

***Interpolate* = 7: Cubic Spline Curve Interpolation**

- This value of *Interpolate* is not available in TriLookupLite.
- Interpolate using a natural cubic spline curve drawn through all the points defined by the pairs of values in the lookup area and the data area.
- This type of interpolation is slower than linear and piecewise parabolic or hyperbolic, because it has to process the values of all table points in order to calculate the interpolated return value. The calculation speed may be important if you are dealing with large 2D or 3D tables and/or have a slow computer.
- All lookup and return values must be numeric. In addition, the lookup values must be constantly ascending or descending. For example, the following array of lookup values is invalid: 2, 3, 3, 4.
- The natural cubic spline is a third degree piecewise polynomial curve that always passes through all the points. The first and second derivatives of the whole curve are continuous and the second derivatives at each end of the curve are equal zero. The shape of the spline curve for any lookup value (X) is determined by ALL table points.
- If there are only two valid lookup points in the table then linear interpolation is performed instead.

***Interpolate* = -1 to -20: Polynomial Curve Interpolation**

- These values of *Interpolate* are not available in TriLookupLite.
- Interpolation is performed using a polynomial curve $Y = c_0 + c_1 \bullet X + c_2 \bullet X^2 + c_3 \bullet X^3 + ... + c_n \bullet X^n$, with order n = -*Interpolate*. The polynomial curve is fitted using the least squares method through the data points given in the lookup area (X values) and the data area (Y values) of the table.
- This type of interpolation should generally be used if data points are scattered around and you wish to return the value from the polynomial trendline drawn through the points, which generally does not pass through all of them. Using the polynomial interpolation allows you to do so directly, without first having to calculate the values of the polynomial coefficients (which you can do using the TVPOLYDATA or THPOLYDATA functions), and then using the obtained coefficients to calculate the return value from the polynomial curve (which you can do using the TPOLY function).
- This type of interpolation is slower than linear and piecewise parabolic or hyperbolic because it has to process the values of all table points in order to calculate the interpolated return value. The calculation speed may be important if you are dealing with large 2D or 3D tables and/or have a slow computer.
- All lookup and return values must be numeric. In addition, the lookup values must be constantly ascending or descending. For example, the following array of lookup values is invalid: 2, 3, 3, 4.
- Although you can specify any order between 1 and 20, you should avoid the values over 15 (i.e., *Interpolate* < -15) because they may cause excessive calculation errors due to precision limits imposed by the 32 bit floating point computation.
- If the specified order n equals or exceeds the number of valid points in the lookup table (p), it is automatically reduced to one less than the number of points (n = p - 1).

- In a general case where the specified order n is less than the number of points minus 1 ($n < p - 1$), the fitted polynomial curve will not pass through all the points (as show by the curve drawn for *Interpolate* = -5 in the example). If you have a large number of points, say over 15, and want the interpolation curve to pass through every single point, you should consider using a different type of interpolation (see *Interpolate* = 4, 5, 6 and 7).
- All derivatives of the polynomial curve are continuous and the shape of the curve for any lookup value (X) is determined by all the points.
- Internally, TriLookup functions calculate the polynomial interpolation curve coefficients after first normalizing the range of lookup values. This is done by performing a linear transformation (mapping) of the original lookup (L) values into L' values which lie in the -1 to +1 range. This procedure helps reduce the calculation errors (caused by the limits in precision of the 32 bit floating point computations) in some cases where the polynomial order **n** is high (for example $n > 15$).

Power Parameter

- Optional parameter, any number, default = 1.
- This parameter is the exponent used in calculating the averaging weights the in the Double Parabolic Piecewise Curve Interpolation (*Interpolate* = 5) and the Double Hyperbolic Piecewise Curve Interpolation (*Interpolate* = 6). The weight used for averaging between the left and the right curve is raised to this power. In a special case for *Power* = 0 the averaging weight is calculated using a sine curve.
- The functions with one lookup variable (TVLOOKUP and THLOOKUP), use only one *Power* parameter. The T2LOOKUP function, which has 2 lookup (independent) variables (X and Y), and T3LOOKUP with 3 lookup variables (X, Y and Z), have separate settings for each lookup variable: *X_power*, *Y_power* and, in case of T3LOOKUP, *Z_power*. However, all simplified versions of TriLookup functions (TVLKP, THLKP, T2LKP and T3LKP), use only the default value of *Power* = 1.
- Note that all references to *Power* below also pertain to *X_power*, *Y_ power* and *Z_ power*.
- The averaging between the left and right curve in the double piecewise curve Interpolation is done in the following way: The two calculated return values for the left and right curves (Y_L and Y_R) are weighted based on how close the lookup value (X) is to the point on the left (X_L) and the point on the right (X_R). It is done in the following way:

$Y = W_L \cdot Y_L + W_R \cdot Y_R$

where W_L and W_R are weights for the left and right curve, respectively. How W_L and W_R are calculated depends on the value of *Power* (P).

For $P <> 0$, the following formulas are used:

For $X <= (X_L + X_R) / 2$

$$W_R = \frac{\left(2\frac{X - X_L}{X_R - X_L}\right)^P}{2}; \quad W_L = 1 - W_R$$

For $X > (X_L + X_R) / 2$

$$W_L = \frac{\left(2\frac{X - X_R}{X_L - X_R}\right)^P}{2}; \quad W_R = 1 - W_L$$

Note that the above formulas ensure that the curve averaging in the X_L and X_R interval is symmetrical between left and right, for any value of Power P.

For a special case of $P = 0$, the averaging weights are calculated using the following sine curve formula:

$$W_R = \frac{\sin\left[\left(\frac{X - X_L}{X_R - X_L}\right) \cdot \pi - \frac{\pi}{2}\right] + 1}{2}; \quad W_L = 1 - W_R$$

- For *Power* = 1 (default), the curve averaging is performed by a simple linear inverse distance weighting. The first derivative of the whole curve is continuous, while the second derivative generally has a discontinuity at each table point.
- For *Power* = 0 (sine curve averaging), both the first and the second derivatives of the whole curve are continuous for *Interpolate* = 5 and also for *Interpolate* = 6 if the return values are constantly ascending or descending.
- **Note**: Although you can use values for the *Power* parameter that are neither 1 or 0, you should be careful because this can produce unexpected results. You should use the *Power* values other than 1 or 0 only if you have special requirements and if you fully understand the outcome.

Missing_pts and Extrapolate Parameters

Missing_pts

- Optional parameter, TRUE or FALSE, default = FALSE.
- This parameter determines whether to allow blank and non-numeric cells in the lookup table. It has no effect when *Interpolate* = 0, in which case the table may contain any values.
  FALSE blank and non-numeric cells are NOT allowed;
  TRUE blank and non-numeric cells are allowed. How the table with missing points (blank and non-numeric cells) will be processed also depends on the extrapolation interval.
- The simplified versions of TriLookup functions (TVLKP, THLKP, T2LKP and T3LKP), use only the default value of *Missing_pts* = FALSE. Therefore, in order to process lookup tables with blank and non-numeric cells, you must use the full versions of the TriLookup functions (TVLOOKUP, THLOOKUP, T2LOOKUP and T3LOOKUP).
- How the missing points will be processed depends on the size of extrapolation interval(s), as shown below.

Extrapolate

- Optional parameter, any number, default = 0 (no extrapolation).
- Determines whether to perform extrapolation and the size of extrapolation interval (how far to extrapolate past the minimum and maximum values in the lookup area).
- The functions with one lookup variable (TVLOOKUP and THLOOKUP), use only one *Extrapolate* parameter. The T2LOOKUP function, which has 2 lookup (independent) variables (X and Y), and T3LOOKUP with 3 lookup variables (X, Y and Z), have separate extrapolation settings for each lookup variable: *X_extrapolate*, *Y_extrapolate* and, in case of T3LOOKUP, *Z_extrapolate*.
- The simplified versions of TriLookup functions (TVLKP, THLKP, T2LKP and T3LKP), use only the default value of *Extrapolate* = 0. Therefore, in order to use extrapolation, or process lookup tables with blank and non-numeric cells, you must use the full versions of the TriLookup functions (TVLOOKUP, THLOOKUP, T2LOOKUP and T3LOOKUP).
- The extrapolation interval (***E***) is determined by the value of the ***Extrapolate*** parameter in the following way:

  For *Extrapolate* >= 0 -> ***E*** = *Extrapolate*

  For *Extrapolate* < 0 -> ***E*** = *Extrapolate* * (Lmin – Lmax)

  where Lmax and Lmin are maximum and minimum values in the lookup area.
- For a zero extrapolation interval (E = 0), the TriLookup functions return #N/A whenever the lookup value falls into a gap in the lookup table, where either lookup and/or return value is missing or invalid. For ***E*** > 0, the return values will be calculated for all lookup points that lay within ***E*** distance from the edges of the gap.
- **Note**: It makes no difference whether the lookup or return value or both are missing or invalid.

Smooth_R2 Parameter

- Optional parameter, TRUE or FALSE, default = FALSE.
- This parameter determines whether to use additional in-between points when calculating the R-squared value (R^2) and the sum of error squares (residuals) of the polynomial curve (Sum(E^2)).
- For ***Smooth_R2* = FALSE**, the R^2 and Sum(E^2) values returned by TVPOLYDATA and THPOLYDATA indicate only how closely the polynomial curve fits the set of table data points, regardless of what the curve looks like between the points. In some cases, parts of the best fit curve (the one with the highest R^2) for *Smooth_R2* = FALSE can be highly unstable, having extreme local minimums or maximums between the data points. However, this will not affect the values of R^2 and Sum(E^2), nor is it obvious from the values of the polynomial coefficients. The only way to discover such instability is to plot the polynomial curve values, calculated at closely spaced X intervals (see the example below).
- For ***Smooth_R2* = TRUE**, the R^2 and Sum(E^2) values returned by TVPOLYDATA and THPOLYDATA indicate how closely **and smoothly** the polynomial curve fits the set of table data points. They are calculated by also taking into account the shape of the curve between the table data points. If parts of a polynomial curve are unstable, having local minimums or maximums between the data points, the value of R^2 will be reduced, and the value of Sum(E^2) increased. As a result, the best fit curve (the one with the highest R^2) picked by TVPOLYDATA and THPOLYDATA will be the one with least instabilities that comes close to all table data points. Generally, this is the curve that you would pick out as the best one from the diagram showing polynomial curves of different orders (see the example). The advantage is that, in order to determine the polynomial curve that best approximates your set of data points, you don’t have to go through the trouble of calculating and plotting a multi curve diagram. All you need to do is specify *Smooth_R2* = TRUE.
- If *Smooth_R2* = TRUE, then TVPOLYDATA and THPOLYDATA calculate (R^2) and Sum(E^2) using the following procedure:
  - Insert a single extra point in the middle of each interval between the table data points.
  - The X and Y coordinates of the extra points are calculated as follows:

$X = (X_L + X_R) / 2$

$Y = (Y_L + Y_R) / 2$

where the L subscripts denote the point on the left, and the R subscripts the point on the right.

  - Calculate R^2 (R-squared value) and Sum(E^2) (sum of error squares), taking into account all table points and the in-between extra points.

- R^2 is an indication of how close the polynomial curve fits the set of table plus extra points. Its value can be between 0 and 1, with $R^2 = 1$ indicating the perfect fit. TVPOLYDATA and THPOLYDATA calculate R^2 from the following formula:

$$R^2 = 1 - \frac{\sum\left(Y_i - \hat{Y}_i\right)^2}{\left(\sum Y_i^2\right) - \frac{\left(\sum Y_i\right)^2}{p}}$$

where Y_i denote Y values of table points and extra in-between points, $\hat{Y}_i$ are the Y values on the polynomial curve, and $\boldsymbol{p}$ is the total number of points (table + extra).

- Sum(E^2) is the sum of error squares (residuals) of a polynomial curve. It is calculated from the following formula:

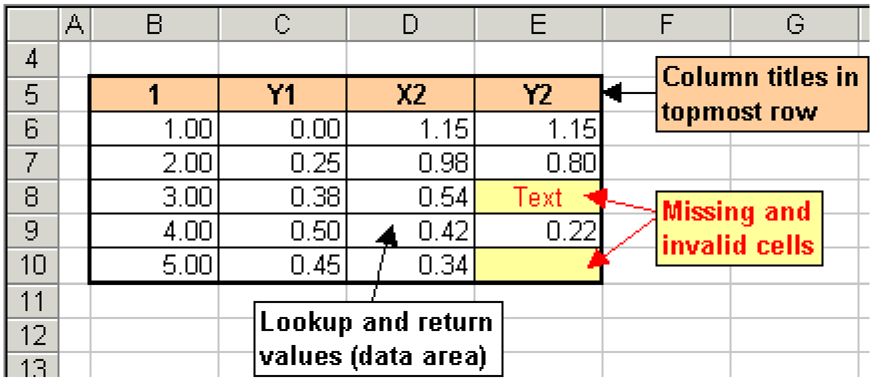
  $$\sum E^2 = \sum\left(Y_i - \hat{Y}_i\right)^2$$

  Sum(E^2) is another indication of how close the polynomial curve fits the set of data + extra points, with lower values indicating a better fit. In case of a perfect fit Sum(E^2) = 0, which corresponds to $R^2 = 1$.

Examples (TriLookup Functions)

TVLOOKUP & TVLKP Examples

The 6-row by 4-column lookup table below is set up for use by the TVLOOKUP and TVLKP functions. It contains column titles in the topmost row and the lookup and return values in the remaining 5 rows. TVLOOKUP and TVLKP use the column titles in order to identify the lookup column and the return column.



1	Y1	X2	Y2
1.00	0.00	1.15	1.15
2.00	0.25	0.98	0.80
3.00	0.38	0.54	Text
4.00	0.50	0.42	0.22
5.00	0.45	0.34	

A
B
C
D
E
F
G
4
5
6
7
8
9
10
11
12
13
Column titles in topmost row
Missing and invalid cells
Lookup and return values (data area)

Search for value = 2.75 in the lookup column titled 1 and return a value from the return column "Y1"; use a third order polynomial interpolation (*Interpolate* = -3).

```
=TVLKP(2.75,$B$5:$E$10,1,"Y1",-3) equals 0.36819308
```

Search for value = 0.75 in the lookup column "X2" and return the corresponding value from the return column "Y1"; use a linear interpolation (*Interpolate* = 4).

```
=TVLKP(0.75,$B$5:$E$10,"X2","Y1",4) equals 0.317954545
```

Same as above, but use the column index numbers instead of column titles (3 instead of “X2” and 2 instead of “Y1”) to specify the lookup and return columns (*Index_mode* = TRUE).

```
=TVLKP(0.75,$B$5:$E$10,3,2,4,,TRUE) equals 0.317954545
```

Search for value = 0.75 in the lookup column "X2" and return a value from the return column "Y2"; use a linear interpolation (*Interpolate* = 4).

```
=TVLKP(0.75,$B$5:$E$10,"X2","Y2",4) equals #VALUE!
```

Same as above, but with *Error_msg* = TRUE in order to get an explanation on what caused TVLKP to return the #VALUE! Error.

```
=TVLKP(0.75,$B$5:$E$10,"X2","Y2",4,TRUE) equals:
      #VALUE! {Err.402} 2 missing or invalid cells found  in Return column titled "Y2"
      (all cells must be numeric for Interpolate < 0 or > 2, and Missing_pts = FALSE).
```

Search for value = 0.75 in the lookup column "X2" and return a value from the return column "Y2"; use the default "exact match" (*Interpolate* = 0).

```
=TVLKP(0.75,$B$5:$E$10,"X2","Y2",,TRUE) equals:
      #N/A {Err.312} Invalid Lookup_value =  .75 (cannot find exact match in Lookup
      Column titled "X2").
```

Same as above, but using the "exact or next lower value" (*Interpolate* = 1) mode, which is similar to the Excel's built in VLOOKUP function.

```
=TVLKP(0.75,$B$5:$E$10,"X2","Y2",1,TRUE) equals Text
```

Search for value = 0.75 in the lookup column "X2" and return a value from the return column "Y2"; use a linear interpolation (*Interpolate* = 4). Also set *Missing_pts* = TRUE to allow processing of lookup column and return column containing missing (empty) and invalid (non-numeric) cells.

```
=TVLOOKUP(0.75,$B$5:$E$10,"X2","Y2",4,,,TRUE,TRUE) equals:
      #N/A {Err.408} Invalid Lookup_value = 0.75 (out of bounds due to missing or
      invalid cells in Return column titled "Y2").
```

Same as above, but with *Extrapolate* = 2. This allows TVLOOKUP to extrapolate up to 2 units away from the last valid cell.

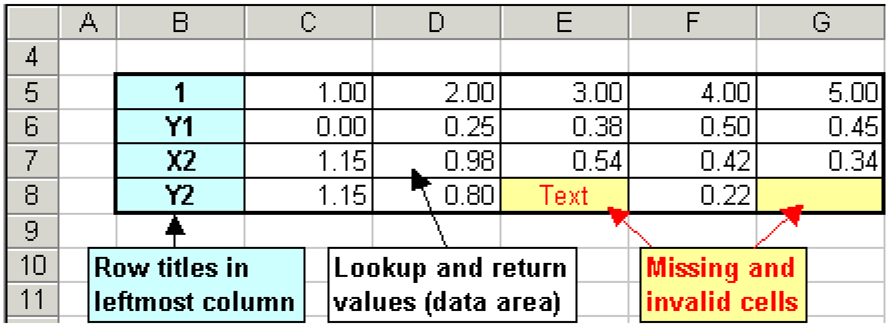
```
=TVLOOKUP(0.75,$B$5:$E$10,"X2","Y2",4,2,,TRUE,TRUE) equals 0.561785714
```

Same as above, but using different lookup column and return column ("Y1" and "X2", respectively). Note: if *Interpolate* <> 0, then the values in the lookup column must be constantly increasing or decreasing.

```
=TVLOOKUP(0.75,$B$5:$E$10,"Y1","X2",4,2,,TRUE,TRUE) equals:
      #VALUE! {Err.310} Invalid Lookup Column titled "Y1" for Interpolate <> 0 (values
      not constantly increasing or decreasing:  .38;  .5;  .45).
```

THLOOKUP & THLKP Examples

The 4-row by 6-column lookup table below is set up for use by the THLOOKUP and THLKP functions. It contains row titles in the leftmost column and the lookup and return values in the remaining 5 columns. THLOOKUP and THLKP use the row titles in order to identify the lookup row and return row.



	A	B	C	D	E	F	G
4							
5		1	1.00	2.00	3.00	4.00	5.00
6		Y1	0.00	0.25	0.38	0.50	0.45
7		X2	1.15	0.98	0.54	0.42	0.34
8		Y2	1.15	0.80	Text	0.22	

Row titles in leftmost column
Lookup and return values (data area)
Missing and invalid cells

Search for value = 2.75 in the lookup row titled 1 and return a value from the return row "Y1"; use a third order polynomial interpolation (*Interpolate* = -3).

```
=THLKP(2.75,$B$5:$G$8,1,"Y1",-3) equals 0.36819308
```

Search for value = 0.75 in the lookup row "X2" and return the corresponding value from the return row "Y1"; use a linear interpolation (*Interpolate* = 4).

```
=THLKP(0.75,$B$5:$G$8,"X2","Y1",4) equals 0.317954545
```

Same as above, but use the row index numbers instead of row titles (3 instead of “X2” and 2 instead of “Y1”) to specify the lookup and return rows (*Index_mode* = TRUE).

```
=THLKP(0.75,$B$5:$G$8,3,2,4,,TRUE) equals 0.317954545
```

Search for value = 0.75 in the lookup row "X2" and return a value from the return row "Y2"; use a linear interpolation (*Interpolate* = 4).

```
=THLKP(0.75,$B$5:$G$8,"X2","Y2",4) equals #VALUE!
```

Same as above, but with *Error_msg* = TRUE in order to get an explanation on what caused THLKP to return the #VALUE! Error.

```
=THLKP(0.75,$B$5:$G$8,"X2","Y2",4,TRUE) equals:
       #VALUE! {Err.401} 2 missing or invalid cells found  in Return row titled "Y2" (all
       cells must be numeric for Interpolate < 0 or > 2, and Missing_pts = FALSE).
```

Search for value = 0.75 in the lookup row "X2" and return a value from the return row "Y2"; use the default "exact match" (*Interpolate* = 0).

```
=THLKP(0.75,$B$5:$G$8,"X2","Y2",,TRUE) equals:
       N/A {Err.312} Invalid Lookup_value =  .75 (cannot find exact match in Lookup Row
       titled "X2").
```

Same as above, but using the "exact or next lower value" (*Interpolate* = 1) mode, which is similar to the Excel's built in VLOOKUP function.

```
=THLKP(0.75,$B$5:$G$8,"X2","Y2",1,TRUE) equals Text
```

Search for value = 0.75 in the lookup row "X2" and return a value from the return row "Y2"; use a linear interpolation (*Interpolate* = 4). Also set *Missing_pts* = TRUE to allow processing of lookup row and return row containing missing (empty) and invalid (non-numeric) cells.

```
=THLOOKUP(0.75,$B$5:$G$8,"X2","Y2",4,,,TRUE,TRUE) equals:
       #N/A {Err.407} Invalid Lookup_value = 0.75 (out of bounds due to missing or
       invalid cells in Return row titled "Y2").
```

Same as above, but with *Extrapolate* = 2. This allows THLOOKUP to extrapolate up to 2 units away from the last valid cell.

```
=THLOOKUP(0.75,$B$5:$G$8,"X2","Y2",4,2,,TRUE,TRUE) equals 0.561785714
```

Same as above, but using different lookup row and return row ("Y1" and "X2", respectively). Note: if *Interpolate* <> 0, then the values in the lookup row must be constantly increasing or decreasing.

```
=THLOOKUP(0.75,$B$5:$G$8,"Y1","X2",4,2,,TRUE,TRUE) equals:
       #VALUE! {Err.310} Invalid Lookup Row titled "Y1" for Interpolate <> 0 (values not
       constantly increasing or decreasing:  .38;  .5;  .45).
```

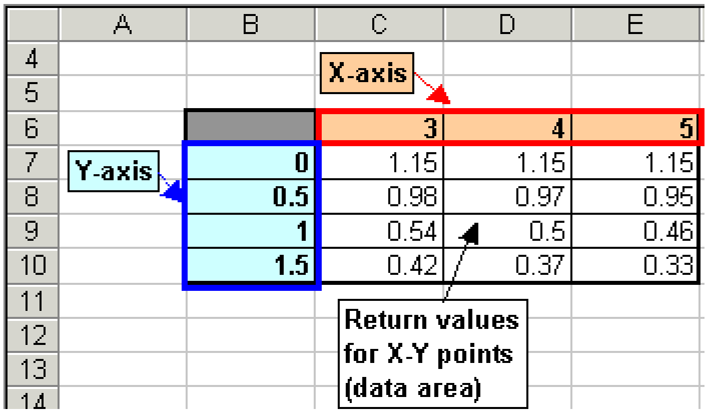
T2LOOKUP & T2LKP Examples

The following examples are available for T2LOOKUP and T2LKP functions:

- Examples Without Missing and Invalid Cells(T2LOOKUP & T2LKP)
- Examples With Missing and Invalid Cells(T2LOOKUP)

T2LOOKUP & T2LKP Examples Without Missing and Invalid Cells

The 5-row by 4-column lookup table below is set up for use by the T2LOOKUP and T2LKP functions. It contains X-axis values in the topmost row, Y-axis values in the leftmost column and the return values in the remaining area. The contents of the top left corner cell is ignored.



	A	B	C	D	E
4					
5					
6			3	4	5
7		0	1.15	1.15	1.15
8		0.5	0.98	0.97	0.95
9		1	0.54	0.5	0.46
10		1.5	0.42	0.37	0.33
11					
12					
13					
14					

Search for X value = 3.5 and Y value = 0.9 in the 2D (X-Y) lookup table and determine the V(x,y) return value; use a linear interpolation for both X and Y (*Interpolate* = 4).

```
=T2LKP(3.5,0.9,$B$6:$E$10,4) equals 0.611
```

Search for X value = 5.5 and Y value = 0.9 in the 2D (X-Y) lookup table and determine the V(x,y) return value; use a linear interpolation for both X and Y (*Interpolate* = 4).

```
=T2LKP(5.5,0.9,$B$6:$E$10,4) equals #N/A
```

Same as above, but with *Error_msg* = TRUE in order to get an explanation on what caused T2LKP to return the #N/A Error.

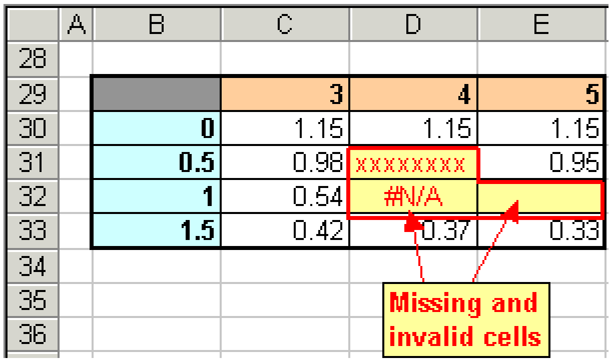
```
=T2LKP(5.5,0.9,$B$6:$E$10,4,TRUE) equals:
      #N/A {Err.311} Invalid X_value =  5.5 (out of bounds: 3 to 5).
```

Same as above, but use T2LOOKUP with *X_extrapolate* = 1. This allows T2LOOKUP to extrapolate up to 1 units away from the last cell in the X direction.

```
=T2LOOKUP(5.5,0.9,$B$6:$E$10,4,4,1,,,,,,TRUE) equals 0.54
```

T2LOOKUP Examples With Missing and Invalid Cells

The 5-row by 4-column table below can be used by T2LOOKUP even though it contains missing (blank) and invalid (non numeric) cells.



	A	B	C	D	E
28					
29			**3**	**4**	**5**
30		**0**	1.15	1.15	1.15
31		**0.5**	0.98	xxxxxxxx	0.95
32		**1**	0.54	#N/A	
33		**1.5**	0.42	0.37	0.33
34					
35					
36					

Search for X value = 3.5 and Y value = 0.9 in the 2D (X-Y) lookup table and determine the V(x,y) return value; use a linear interpolation for both X and Y (4).

```
=T2LOOKUP(3.5,0.9,$B$29:$E$33,4,4) equals #VALUE!
```

Same as above, but with *Error_msg* = TRUE in order to get an explanation on what caused T2LOOKUP to return the #VALUE! Error.

```
=T2LOOKUP(3.5,0.9,$B$29:$E$33,4,4,,,,,,,TRUE) equals:
       #VALUE! {Err.403} 3 missing or invalid cells found in data area (all cells must be
       numeric for Missing_pts = FALSE).
```

Same as above, but with *Missing_pts* = TRUE in order to allow processing of missing (empty) and invalid (non-numeric) cells.

```
=T2LOOKUP(3.5,0.9,$B$29:$E$33,4,4,,,,,,TRUE,TRUE) equals:
       #N/A {Err.409} Invalid lookup point [X_value = 3.5, Y_value = 0.9], (out of bounds
       due to missing or invalid cells in data area).
```

Same as above, but with *X_extrapolate* = 1 and *Y_extrapolate* = 1. This allows T2LOOKUP to extrapolate up to 1 units away from the last valid cell in both X and Y directions.

```
=T2LOOKUP(3.5,0.9,$B$29:$E$33,4,4,1,1,,,,TRUE,TRUE) equals 0.6265
```

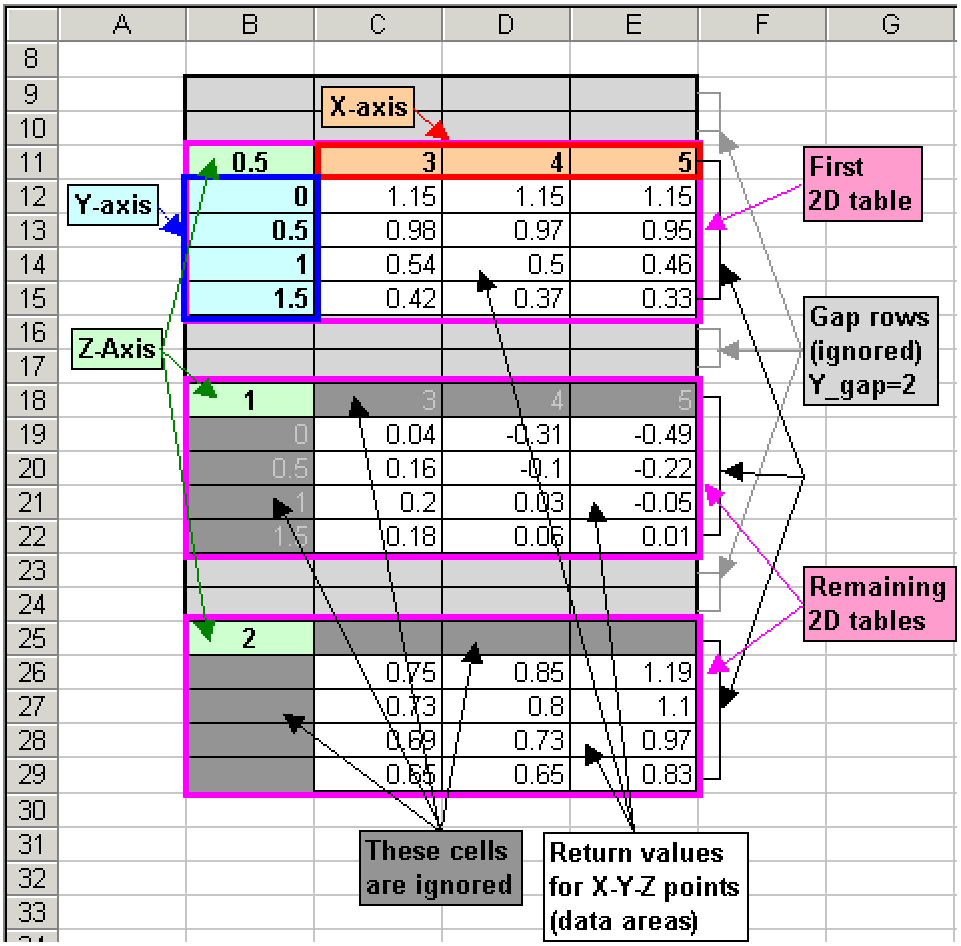
T3LOOKUP & T3LKP Examples

The following examples are available for T3LOOKUP and T3LKP functions:

- Single Area 3D Table Examples (T3LOOKUP)
- Multi Area 3D Table Examples(T3LOOKUP & T3LKP)
- Skewed 3D Table Examples (T3LOOKUP)

T3LOOKUP Single Area 3D Table Examples

The 21-row by 4-column lookup table below is set up for use by the T3LOOKUP function. It is a single area 3D table containing 3 component 2D tables, separated by 2 separator rows (*Table_Ygap* = 2). Each 2D table has 5 rows (*Table_Ysize* = 5). The first (topmost) 2D table contains X-axis values in its topmost row and Y-axis values in its leftmost column, while the topmost rows and the leftmost columns of the remaining 2D tables are ignored. The Z-axis values for each 2D table are located in the top-left corner cells. The return values, which depend on X, Y and Z, are in the remaining area.



	A	B	C	D	E	F	G
8							
9							
10							
11		0.5	3	4	5		
12		0	1.15	1.15	1.15		
13		0.5	0.98	0.97	0.95		
14		1	0.54	0.5	0.46		
15		1.5	0.42	0.37	0.33		
16							
17							
18		1	3	4	5		
19		0	0.04	-0.31	-0.49		
20		0.5	0.16	-0.1	-0.22		
21		1	0.2	0.03	-0.05		
22		1.5	0.18	0.06	0.01		
23							
24							
25		2					
26			0.75	0.85	1.19		
27			0.73	0.8	1.1		
28			0.69	0.73	0.97		
29			0.65	0.65	0.83		
30							
31							
32							
33							

Search for X value = 3.5, Y value = 0.9 and Z value = 1.25 in the single area 3D (X-Y-Z) lookup table and determine the V(x,y,z) return value; use the "closest value" matching along X, Y and Z axes (*X/Y/Z_interpolate* = 3).

```
=T3LOOKUP(3.5,0.9,1.25,$B$9:$E$29,2,5,3,3,3,,,,,,,,,TRUE) equals: 0.03
```

Same as above, but use a linear interpolation along X, Y and Z axes (*X/Y/Z_interpolate* = 4).

```
=T3LOOKUP(3.5,0.9,1.25,$B$9:$E$29,2,5,4,4,4,,,,,,,,,TRUE) equals 0.25375
```

Same as above, but use a double parabolic piecewise curve interpolation along the X-axis (*X_interpolate* = 5), a polynomial curve interpolation with order n = 3 along the Y-axis (*Y_interpolate* = -3) and a cubic spline curve interpolation along the Z-axis (*Z_interpolate* = 7).

```
=T3LOOKUP(3.5,0.9,1.25,$B$9:$E$29,2,5,5,-3,7,,,,,,,,,TRUE) equals 0.064854531
```

Search for X value = 3.5, Y value = 0.9 and Z value = 2.5 in the single area 3D (X-Y-Z) lookup table and determine the V(x,y,z) return value; use a linear interpolation along X, Y and Z axes (X/Y/Z_interpolate = 4).

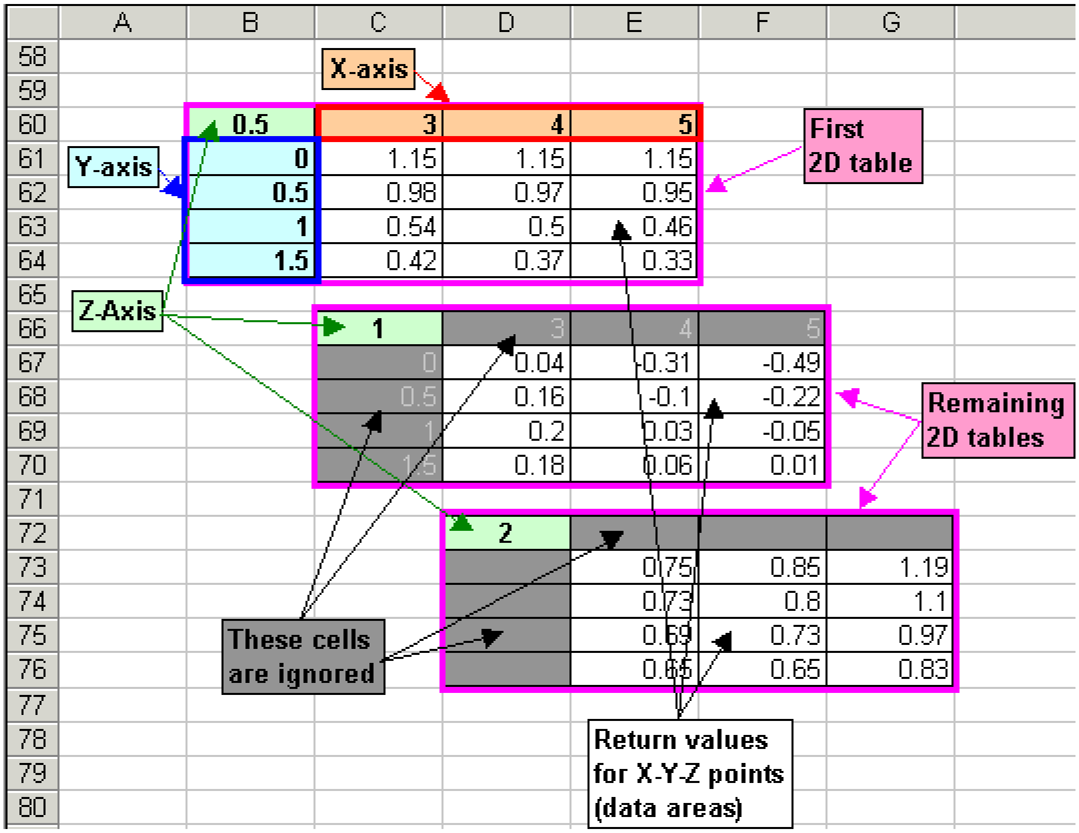
```
=T3LOOKUP(3.5,0.9,2.5,B9:E29,2,5,4,4,4,,,,,,,,,TRUE) equals:
       #N/A {Err.311} Invalid Z_value =  2.5 (out of bounds: 0.5 to 2).
```

Same as above, but add *Z_extrapolate* = 0.5 to allow T3LOOKUP to extrapolate up to 0.5 units past the minimum and maximum Z-axis values.

```
=T3LOOKUP(3.5,0.9,1.25,B9:E29,2,5,4,4,4,,,0.5,,,,,,TRUE) equals 0.25375
```

T3LOOKUP & T3LKP Multi Area 3D Table Examples

The three 5-row by 4-column tables below together make up a multi area 3D lookup table, set up for use by the T3LOOKUP and T3LKP functions. Note that the individual 2D tables don't have to be in order and can be scattered throughout the worksheet. The first (topmost) 2D table contains X-axis values in its topmost row and Y-axis values in its leftmost column, while the topmost rows and the leftmost columns of the remaining 2D tables are ignored. The Z-axis values for each 2D table are located in the top-left corner cells. The return values, which depend on X, Y and Z are in the remaining areas. Note that, when specifying a multi area table as the *Table_XYZ* parameter, you must enclose it in parentheses. Otherwise, it will be interpreted as more than one parameter, which will cause an error.



	A	B	C	D	E	F	G
58							
59							
60		0.5	3	4	5		
61		0	1.15	1.15	1.15		
62		0.5	0.98	0.97	0.95		
63		1	0.54	0.5	0.46		
64		1.5	0.42	0.37	0.33		
65							
66			1	3	4	5	
67			0	0.04	-0.31	-0.49	
68			0.5	0.16	-0.1	-0.22	
69			1	0.2	0.03	-0.05	
70			1.5	0.18	0.06	0.01	
71							
72				2			
73					0.75	0.85	1.19
74					0.73	0.8	1.1
75					0.69	0.73	0.97
76					0.65	0.65	0.83
77							
78							
79							
80							

Search for X value = 3.5, Y value = 0.9 and Z value = 1.25 in the multi area 3D (X-Y-Z) lookup table and determine the V(x,y,z) return value; use a linear interpolation along X, Y and Z axes (*Interpolate* = 4).

`=T3LKP(3.5,0.9,1.25,(B60:E64,C66:F70,D72:G76),4,TRUE) equals 0.25375`

Same as above, but specify only the top left cells for the second and third 2D table. T3LOOKUP and T3LKP assume that all 2D tables are of the same size in X and Y directions (have the same number of rows and columns) as the first one.

`=T3LKP(3.5,0.9,1.25,(B60:E64,C66,D72),4,TRUE) equals 0. 25375`

Same as above, but use different types of interpolation in the X, Y and Z directions: *X_interpolate* = 4 (linear), *Y_interpolate* = 7 (spline) and *Z_interpolate* = 5 (double parabolic). For this you must use the T3LOOKUP function.

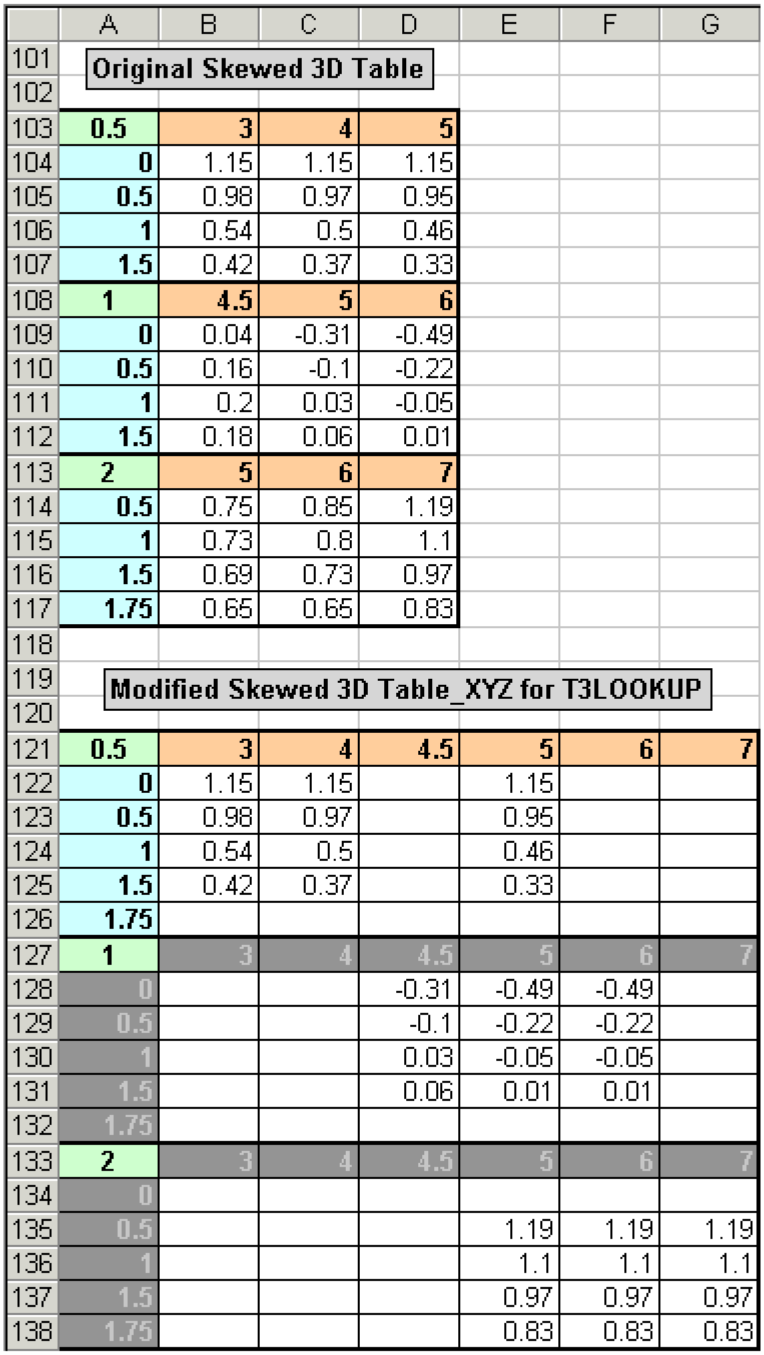
`=T3LOOKUP(3.5,0.9,1.25,(B60:E64,C66,D72),,,4,7,5,,,,,,,,,TRUE) equals 0.059425`

Same as above, but the multiple area range specified as the *Table_XYZ* parameter not enclosed it in parentheses. T3LOOKUP returns the Excel #VALUE! error code because too many parameters are specified.

`=T3LOOKUP(3.5,0.9,1.25,B60:E64,C66,D72,,,4,7,5,,,,,,,,,TRUE) equals #VALUE!`

T3LOOKUP Skewed 3D Table Examples

The two 3D tables below demonstrate how you can use T3LOOKUP to retrieve information from skewed 3D tables in which the component 2D tables have different values along X and Y axes. Note that many of the return values in the data area of the modified table are left blank. Therefore, you must set *Missing_pts* = TRUE. In some cases it may also be necessary to enable extrapolation by assigning *X/Y/Z_extrapolate* parameters non zero values.



	A	B	C	D	E	F	G
101	Original Skewed 3D Table						
102							
103	0.5	3	4	5			
104	0	1.15	1.15	1.15			
105	0.5	0.98	0.97	0.95			
106	1	0.54	0.5	0.46			
107	1.5	0.42	0.37	0.33			
108	1	4.5	5	6			
109	0	0.04	-0.31	-0.49			
110	0.5	0.16	-0.1	-0.22			
111	1	0.2	0.03	-0.05			
112	1.5	0.18	0.06	0.01			
113	2	5	6	7			
114	0.5	0.75	0.85	1.19			
115	1	0.73	0.8	1.1			
116	1.5	0.69	0.73	0.97			
117	1.75	0.65	0.65	0.83			
118							
119	Modified Skewed 3D Table_XYZ for T3LOOKUP						
120							
121	0.5	3	4	4.5	5	6	7
122	0	1.15	1.15		1.15		
123	0.5	0.98	0.97		0.95		
124	1	0.54	0.5		0.46		
125	1.5	0.42	0.37		0.33		
126	1.75						
127	1	3	4	4.5	5	6	7
128	0			-0.31	-0.49	-0.49	
129	0.5			-0.1	-0.22	-0.22	
130	1			0.03	-0.05	-0.05	
131	1.5			0.06	0.01	0.01	
132	1.75						
133	2	3	4	4.5	5	6	7
134	0						
135	0.5				1.19	1.19	1.19
136	1				1.1	1.1	1.1
137	1.5				0.97	0.97	0.97
138	1.75				0.83	0.83	0.83

Search for X value = 5, Y value = 0.9 and Z value = 1.25 in the single area 3D (X-Y-Z) lookup table and determine the V(x,y,z) return value; use a double parabolic piecewise curve interpolation along X, Y and Z axes (*X/Y/Z_interpolate* = 5); set *Missing_pts* = TRUE

```
=T3LOOKUP(5.7,0.9,1.25,$A$121:$G$138,0,6,5,5,5,,,,,,,,TRUE,TRUE) equals -0.1000785
```

Search for X value = 4.2, Y value = 0.9 and Z value = 1.25 in the single area 3D (X-Y-Z) lookup table and determine the V(x,y,z) return value; use linear interpolation along X, Y and Z axes (*X/Y/Z_interpolate* = 4); set *Missing_pts* = TRUE

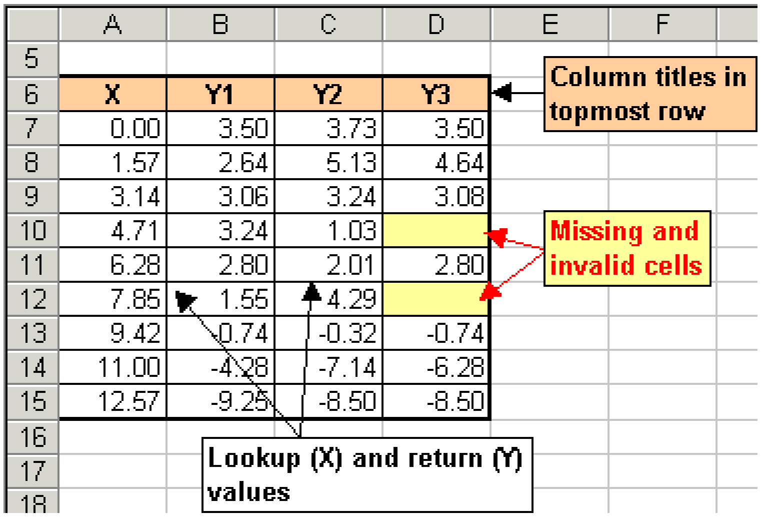
```
=T3LOOKUP(4.2,0.9,1.25,$A$121:$G$138,0,6,4,4,4,,,,,,,,TRUE,TRUE) equals:
       #N/A {Err.421} Invalid lookup point [X_value = 4.2, Y_value = 0.9, Z_value =
       1.25], (out of bounds due to missing or invalid cells in data area).
```

Same as above, but allow extrapolation up to 1.5 units along X, Y and Z axes (*X/Y/Z_extrapolate* = 1.5).

```
=T3LOOKUP(4.2,0.9,1.25,$A$121:$G$138,0,6,4,4,4,1.5,1.5,1.5,,,,,TRUE,TRUE) equals 0.3221
```

TVPOLYDATA Examples

The 10-row by 4-column lookup table below is set up for use by the TVPOLYDATA function. It contains column titles in the topmost row and the lookup (X) and return (Y) values in the remaining 9 rows. TVPOLYDATA uses the column titles in order to identify the lookup column and return column.



	A	B	C	D
6	X	Y1	Y2	Y3
7	0.00	3.50	3.73	3.50
8	1.57	2.64	5.13	4.64
9	3.14	3.06	3.24	3.08
10	4.71	3.24	1.03	
11	6.28	2.80	2.01	2.80
12	7.85	1.55	4.29	
13	9.42	-0.74	-0.32	-0.74
14	11.00	-4.28	-7.14	-6.28
15	12.57	-9.25	-8.50	-8.50

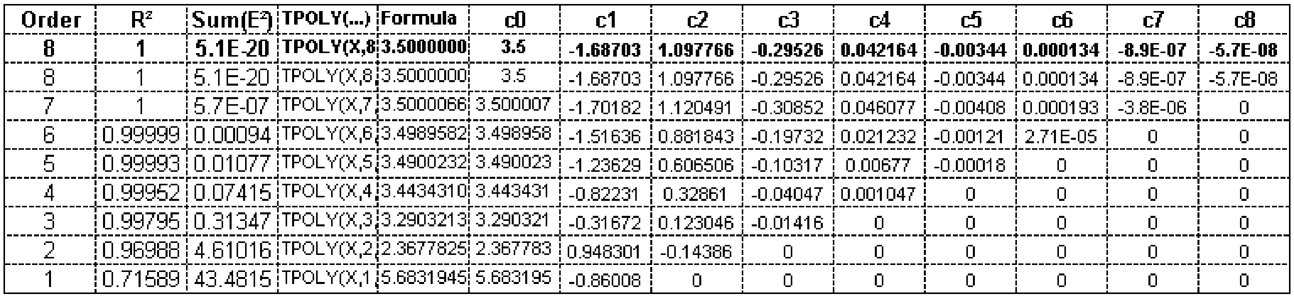
Column titles in topmost row

Missing and invalid cells

Lookup (X) and return (Y) values

For lookup (X) column "X" and return (Y) column "Y1" calculate the coefficients of all polynomial curves; maximum order = 8; use array formula.

`{=TVPOLYDATA($A$6:$D$15,"X","Y1",8)} equals:`



Order	R²	Sum(E²)	TPOLY(...)	Formula	c0	c1	c2	c3	c4	c5	c6	c7	c8
8	**1**	**5.1E-20**	**TPOLY(X,8**	**3.5000000**	**3.5**	**-1.68703**	**1.097766**	**-0.29526**	**0.042164**	**-0.00344**	**0.000134**	**-8.9E-07**	**-5.7E-08**
8	1	5.1E-20	TPOLY(X,8	3.5000000	3.5	-1.68703	1.097766	-0.29526	0.042164	-0.00344	0.000134	-8.9E-07	-5.7E-08
7	1	5.7E-07	TPOLY(X,7	3.5000066	3.500007	-1.70182	1.120491	-0.30852	0.046077	-0.00408	0.000193	-3.8E-06	0
6	0.99999	0.00094	TPOLY(X,6	3.4989582	3.498958	-1.51636	0.881843	-0.19732	0.021232	-0.00121	2.71E-05	0	0
5	0.99993	0.01077	TPOLY(X,5	3.4900232	3.490023	-1.23629	0.606506	-0.10317	0.00677	-0.00018	0	0	0
4	0.99952	0.07415	TPOLY(X,4	3.4434310	3.443431	-0.82231	0.32861	-0.04047	0.001047	0	0	0	0
3	0.99795	0.31347	TPOLY(X,3	3.2903213	3.290321	-0.31672	0.123046	-0.01416	0	0	0	0	0
2	0.96988	4.61016	TPOLY(X,2	2.3677825	2.367783	0.948301	-0.14386	0	0	0	0	0	0
1	0.71589	43.4815	TPOLY(X,1	5.6831945	5.683195	-0.86008	0	0	0	0	0	0	0

Note that, in the above example, you can also use the column index numbers to select the lookup and return columns (1 instead of “X” and 2 instead of “Y1”), by specifying *Index_mode* = TRUE:

`{=TVPOLYDATA($A$6:$D$15,1,2,8,,,,,TRUE)}`

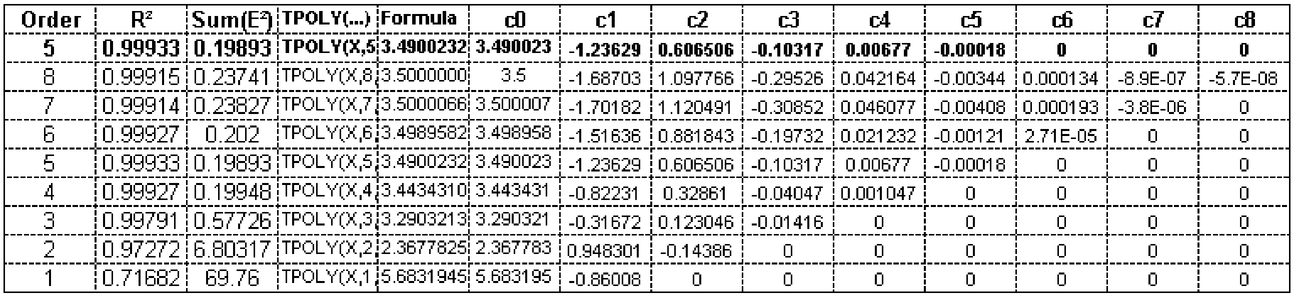
The following strings are returned in the "TPOLY(…)" and "Formula" rows in the above table for Order = 4:

```
TPOLY(X,4,{3.4434310371708,-0.82230762016921,0.328609594844368,-4.04670971229965E-
        02,1.04673785827208E-03})
```

```
3.4434310371708-0.82230762016921*X+0.328609594844368*X^2-4.04670971229965E-
        02*X^3+1.04673785827208E-03*X^4
```

Same as above, but specify *Smooth_R2* = TRUE to use an additional point in-between each two table points when calculating R² and Sum(E²). Note that in this case the best fit is achieved with a the 5th order curve.

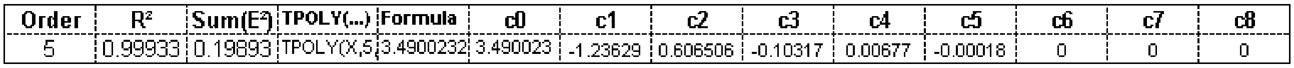
`{=TVPOLYDATA($A$6:$D$15,"X","Y1",8,TRUE)} equals:`



Order	R^2	Sum(E^2)	TPOLY(...)	Formula	c0	c1	c2	c3	c4	c5	c6	c7	c8
5	**0.99933**	**0.19893**	**TPOLY(X,5**	**3.4900232**	**3.490023**	**-1.23629**	**0.606506**	**-0.10317**	**0.00677**	**-0.00018**	**0**	**0**	**0**
8	0.99915	0.23741	TPOLY(X,8	3.5000000	3.5	-1.68703	1.097766	-0.29526	0.042164	-0.00344	0.000134	-8.9E-07	-5.7E-08
7	0.99914	0.23827	TPOLY(X,7	3.5000066	3.500007	-1.70182	1.120491	-0.30852	0.046077	-0.00408	0.000193	-3.8E-06	0
6	0.99927	0.202	TPOLY(X,6	3.4989582	3.498958	-1.51636	0.881843	-0.19732	0.021232	-0.00121	2.71E-05	0	0
5	0.99933	0.19893	TPOLY(X,5	3.4900232	3.490023	-1.23629	0.606506	-0.10317	0.00677	-0.00018	0	0	0
4	0.99927	0.19948	TPOLY(X,4	3.4434310	3.443431	-0.82231	0.32861	-0.04047	0.001047	0	0	0	0
3	0.99791	0.57726	TPOLY(X,3	3.2903213	3.290321	-0.31672	0.123046	-0.01416	0	0	0	0	0
2	0.97272	6.80317	TPOLY(X,2	2.3677825	2.367783	0.948301	-0.14386	0	0	0	0	0	0
1	0.71682	69.76	TPOLY(X,1	5.6831945	5.683195	-0.86008	0	0	0	0	0	0	0

Same as above, but display only the best fit curve.

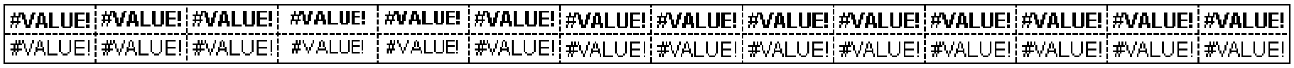
```
{=TVPOLYDATA($A$6:$D$15,"X","Y1",8, TRUE)} equals:
```



Order	R^2	Sum(E^2)	TPOLY(...)	Formula	c0	c1	c2	c3	c4	c5	c6	c7	c8
5	0.99933	0.19893	TPOLY(X,5	3.4900232	3.490023	-1.23629	0.606506	-0.10317	0.00677	-0.00018	0	0	0

For lookup (X) column "X" and return (Y) column "Y3" return the coefficients the best fit polynomial curve; maximum order = 8; use array formula.

```
{=TVPOLYDATA($A$6:$D$15,"X","Y3",8)} equals:
```



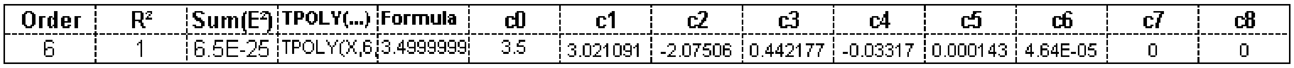
#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!

Same as above, but add a cell with the same formula with *Error_msg* = TRUE to return a detailed text error message indicating the cause of the error.

```
=TVPOLYDATA($A$6:$D$15,"X","Y3",8,,,,TRUE) equals:
       #VALUE! {Err.402} 2 missing or invalid cells found  in Return column titled "Y3"
       (all cells must be numeric for Missing_pts = FALSE).
```

Same as above, but set *Missing_pts* = TRUE. Note that the maximum order has been reduced to 6 because of the two missing X-Y points.

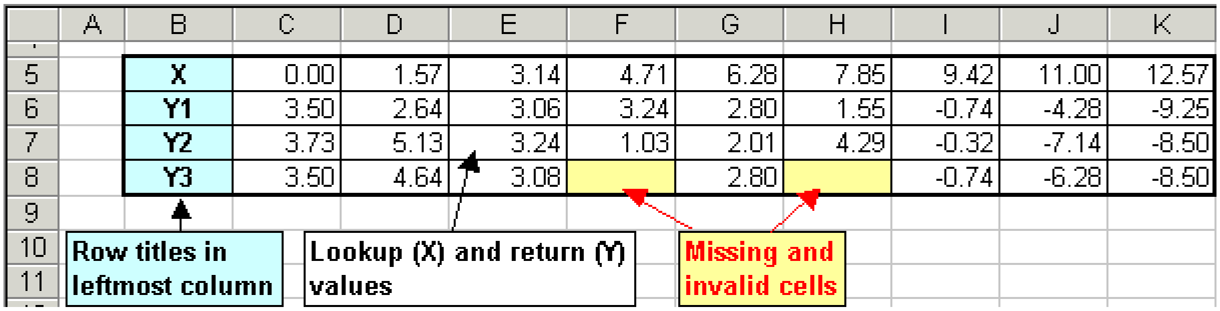
```
{=TVPOLYDATA($A$6:$D$15,"X","Y3",8,,,TRUE)} equals:
```



Order	R^2	Sum(E^2)	TPOLY(...)	Formula	c0	c1	c2	c3	c4	c5	c6	c7	c8
6	1	6.5E-25	TPOLY(X,6	3.4999999	3.5	3.021091	-2.07506	0.442177	-0.03317	0.000143	4.64E-05	0	0

THPOLYDATA Examples

The 4-row by 10-column lookup table below is set up for use by the THPOLYDATA function. It contains row titles in the leftmost column and the lookup (X) and return (Y) values in the remaining 9 columns. THPOLYDATA uses the row titles in order to identify the lookup row and return row.

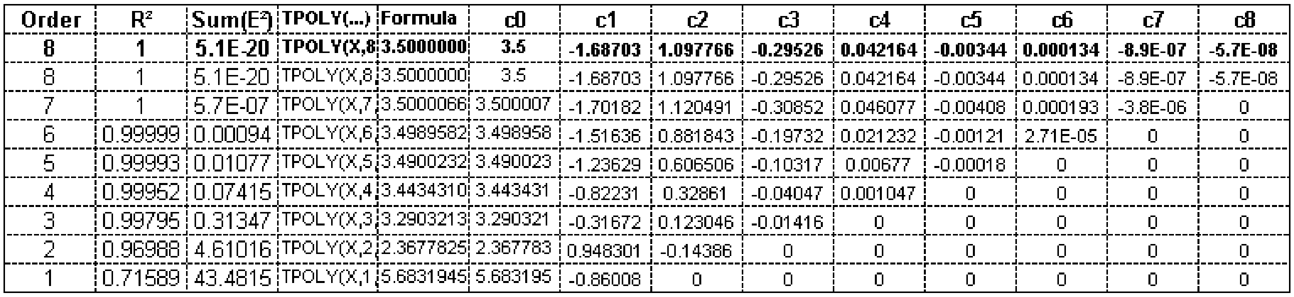


	A	B	C	D	E	F	G	H	I	J	K
5		X	0.00	1.57	3.14	4.71	6.28	7.85	9.42	11.00	12.57
6		Y1	3.50	2.64	3.06	3.24	2.80	1.55	-0.74	-4.28	-9.25
7		Y2	3.73	5.13	3.24	1.03	2.01	4.29	-0.32	-7.14	-8.50
8		Y3	3.50	4.64	3.08		2.80		-0.74	-6.28	-8.50

9
10
11
Row titles in leftmost column
Lookup (X) and return (Y) values
Missing and invalid cells

For lookup (X) row "X" and return (Y) row "Y1" calculate the coefficients of all polynomial curves; maximum order = 8; use array formula.

`{=THPOLYDATA($B$5:$K$8,"X","Y1",8)} equals:`



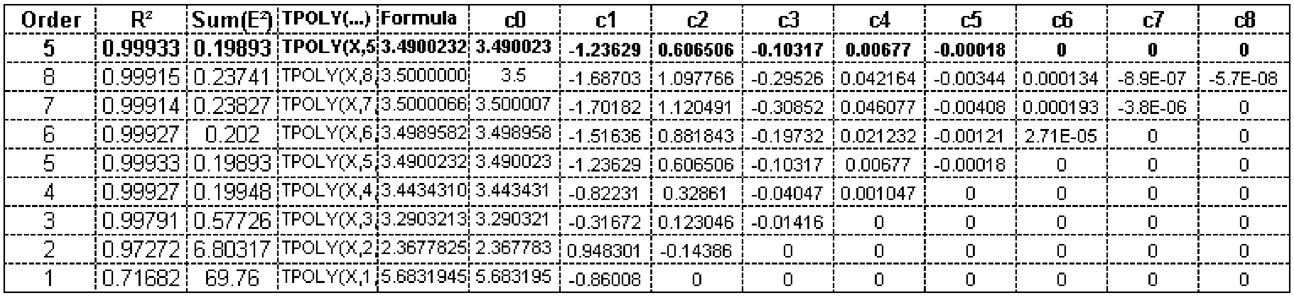
Order	R^2	Sum(E^2)	TPOLY(...)	Formula	c0	c1	c2	c3	c4	c5	c6	c7	c8
8	**1**	**5.1E-20**	**TPOLY(X,8**	**3.5000000**	**3.5**	**-1.68703**	**1.097766**	**-0.29526**	**0.042164**	**-0.00344**	**0.000134**	**-8.9E-07**	**-5.7E-08**
8	1	5.1E-20	TPOLY(X,8	3.5000000	3.5	-1.68703	1.097766	-0.29526	0.042164	-0.00344	0.000134	-8.9E-07	-5.7E-08
7	1	5.7E-07	TPOLY(X,7	3.5000066	3.500007	-1.70182	1.120491	-0.30852	0.046077	-0.00408	0.000193	-3.8E-06	0
6	0.99999	0.00094	TPOLY(X,6	3.4989582	3.498958	-1.51636	0.881843	-0.19732	0.021232	-0.00121	2.71E-05	0	0
5	0.99993	0.01077	TPOLY(X,5	3.4900232	3.490023	-1.23629	0.606506	-0.10317	0.00677	-0.00018	0	0	0
4	0.99952	0.07415	TPOLY(X,4	3.4434310	3.443431	-0.82231	0.32861	-0.04047	0.001047	0	0	0	0
3	0.99795	0.31347	TPOLY(X,3	3.2903213	3.290321	-0.31672	0.123046	-0.01416	0	0	0	0	0
2	0.96988	4.61016	TPOLY(X,2	2.3677825	2.367783	0.948301	-0.14386	0	0	0	0	0	0
1	0.71589	43.4815	TPOLY(X,1	5.6831945	5.683195	-0.86008	0	0	0	0	0	0	0

Note that, in the above example, you can also use the row index numbers to select the lookup and return rows (1 instead of “X” and 2 instead of “Y1”), by specifying *Index_mode* = TRUE:

`{=THPOLYDATA($B$5:$K$8,1,2,8,,,,,TRUE)}`

Same as above, but specify *Smooth_R2* = TRUE to use an additional point in-between each two table points when calculating R^2 and Sum(E^2). Note that in this case the best fit is achieved with a the 5th order curve.

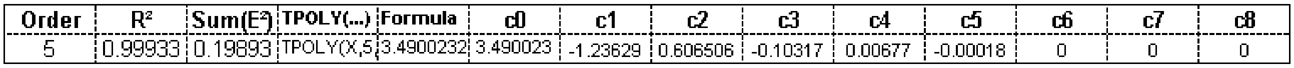
`{=THPOLYDATA($B$5:$K$8,"X","Y1",8,TRUE)} equals:`



Order	R^2	Sum(E^2)	TPOLY(...)	Formula	c0	c1	c2	c3	c4	c5	c6	c7	c8
5	**0.99933**	**0.19893**	**TPOLY(X,5**	**3.4900232**	**3.490023**	**-1.23629**	**0.606506**	**-0.10317**	**0.00677**	**-0.00018**	**0**	**0**	**0**
8	0.99915	0.23741	TPOLY(X,8	3.5000000	3.5	-1.68703	1.097766	-0.29526	0.042164	-0.00344	0.000134	-8.9E-07	-5.7E-08
7	0.99914	0.23827	TPOLY(X,7	3.5000066	3.500007	-1.70182	1.120491	-0.30852	0.046077	-0.00408	0.000193	-3.8E-06	0
6	0.99927	0.202	TPOLY(X,6	3.4989582	3.498958	-1.51636	0.881843	-0.19732	0.021232	-0.00121	2.71E-05	0	0
5	0.99933	0.19893	TPOLY(X,5	3.4900232	3.490023	-1.23629	0.606506	-0.10317	0.00677	-0.00018	0	0	0
4	0.99927	0.19948	TPOLY(X,4	3.4434310	3.443431	-0.82231	0.32861	-0.04047	0.001047	0	0	0	0
3	0.99791	0.57726	TPOLY(X,3	3.2903213	3.290321	-0.31672	0.123046	-0.01416	0	0	0	0	0
2	0.97272	6.80317	TPOLY(X,2	2.3677825	2.367783	0.948301	-0.14386	0	0	0	0	0	0
1	0.71682	69.76	TPOLY(X,1	5.6831945	5.683195	-0.86008	0	0	0	0	0	0	0

Same as above, but display only the best fit curve. equals:

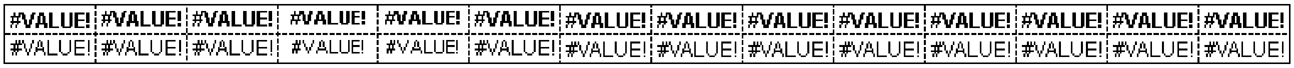
`{=THPOLYDATA($B$5:$K$8,"X","Y1",8,TRUE)}`



Order	R^2	Sum(E^2)	TPOLY(...)	Formula	c0	c1	c2	c3	c4	c5	c6	c7	c8
5	0.99933	0.19893	TPOLY(X,5	3.4900232	3.490023	-1.23629	0.606506	-0.10317	0.00677	-0.00018	0	0	0

For lookup (X) row "X" and return (Y) row "Y3" return the coefficients the best fit polynomial curve; maximum order = 8; use array formula.

```
{=THPOLYDATA($B$5:$K$8,"X","Y3",8)} equals:
```



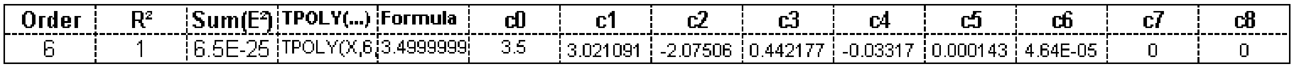
#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!

Same as above, but add a cell with the same formula with *Error_msg* = TRUE to return a detailed text error message indicating the cause of the error.

```
=THPOLYDATA($B$5:$K$8,"X","Y3",8,,,,TRUE) equals:
      #VALUE! {Err.402} 2 missing or invalid cells found  in Return row titled "Y3" (all
      cells must be numeric for Missing_pts = FALSE).
```

Same as above, but set *Missing_pts* = TRUE. Note that the maximum order has been reduced to 6 because of the two missing X-Y points.

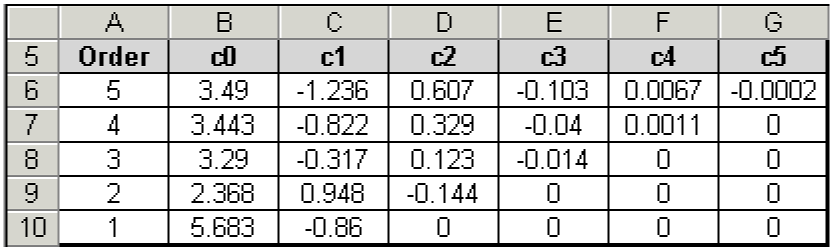
```
{=THPOLYDATA($B$5:$K$8,"X","Y3",8,,,TRUE)} equals:
```



Order	R²	Sum(E²)	TPOLY(...)	Formula	c0	c1	c2	c3	c4	c5	c6	c7	c8
6	1	6.5E-25	TPOLY(X,6	3.4999999	3.5	3.021091	-2.07506	0.442177	-0.03317	0.000143	4.64E-05	0	0

TPOLY Examples

The table below contains coefficients for polynomial curves of order 1 to 5. The coefficients are arranged in the ascending order (c0, c1, c2, etc), so that they can be used by the TPOLY function. Similar tables are returned by TVPOLYDATA and THPOLYDATA functions.



	A	B	C	D	E	F	G
5	**Order**	**c0**	**c1**	**c2**	**c3**	**c4**	**c5**
6	5	3.49	-1.236	0.607	-0.103	0.0067	-0.0002
7	4	3.443	-0.822	0.329	-0.04	0.0011	0
8	3	3.29	-0.317	0.123	-0.014	0	0
9	2	2.368	0.948	-0.144	0	0	0
10	1	5.683	-0.86	0	0	0	0

Calculate the (Y) value of the 5th order polynomial curve for X = 2.3, using the coefficients from the above table.

`=TPOLY(6.5,$A$6,$B$6:$G$6) equals 2.4547125`

Calculate the second derivative (d^2Y/dX^2) of the 5th order polynomial curve for X = 2.3, using the coefficients from the above table.

`=TPOLY(6.5,$A$6,$B$6:$G$6,2) equals -0.5046`

Calculate the (Y) value of the 4th order polynomial curve for X = 6.5, using the coefficients from the above table.

`=TPOLY(6.5,$A$7,$B$7:$F$7) equals 2.97881875`

Same as above, but specify the polynomial coefficients as an inline array, starting from c0. The text of this formula can be copied from the "TPOLY(…)" column returned by TVPOLYDATA and THPOLYDATA.

`=TPOLY(6.5,4,{3.443,-0.822,0.329,-0.04,0.0011}) equals 2.97881875`

Same as above, but using an inline polynomial formula. The text of this formula can be copied from the "Formula" column returned by TVPOLYDATA and THPOLYDATA.

`=3.443-0.822*6.5+0.329*6.5^2-0.04*6.5^3+0.0011*6.5^4 equals 2.97881875`

Examples (Parameters)

Interpolate Examples

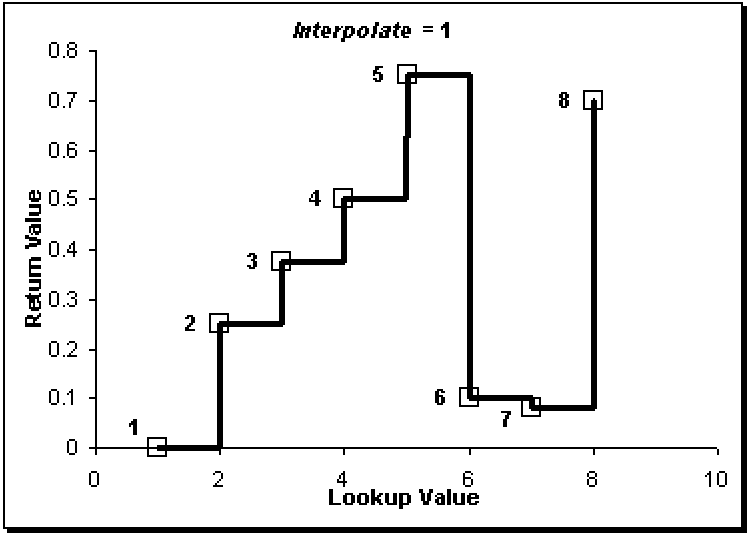
The following examples are available for the *Interpolate* parameter, based on the **type of Interpolation**:

- *Interpolate* = 1: Exact Match or Next Lower Value
- *Interpolate* = 2: Exact Match or Next Higher Value
- *Interpolate* = 3: Closest value
- *Interpolate* = 4: Linear Interpolation
- *Interpolate* = 5: Double Parabolic Piecewise Curve Interpolation
- *Interpolate* = 6: Double Hyperbolic Piecewise Curve Interpolation
- *Interpolate* = 7: Cubic Spline Curve Interpolation
- *Interpolate* = -1 to -20: Polynomial Curve Interpolation

Interpolate = 1: Exact Match or Next Lower Value Example

The example below shows a graph of values returned by THLOOKUP for *Interpolate* = 1.

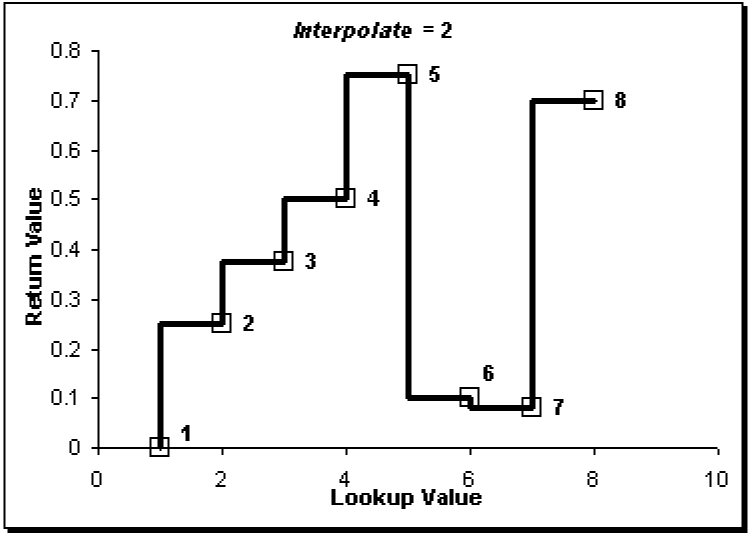
Lookup	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00
Return	0.00	0.25	0.38	0.50	0.75	0.10	0.08	0.70



Interpolate = 2: Exact Match or Next Higher Value Example

The example below shows a graph of values returned by THLOOKUP for *Interpolate* = 2.

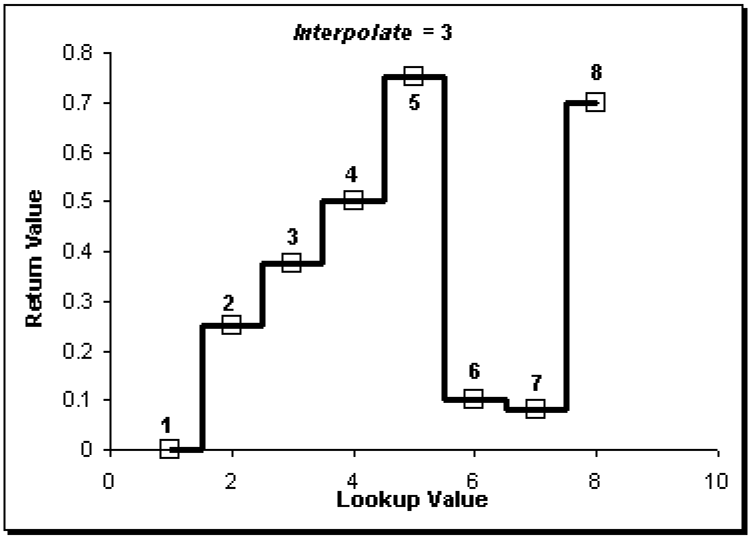
Lookup	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00
Return	0.00	0.25	0.38	0.50	0.75	0.10	0.08	0.70



Interpolate = 3: Closest Value Example

The example below shows a graph of values returned by THLOOKUP for *Interpolate* = 3.

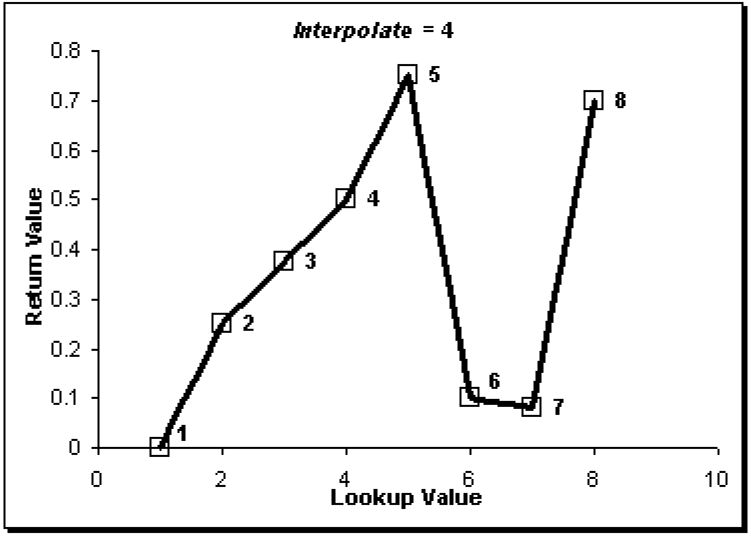
Lookup	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00
Return	0.00	0.25	0.38	0.50	0.75	0.10	0.08	0.70



Interpolate = 4: Linear Interpolation Example

The example below shows a graph of values returned by THLOOKUP for *Interpolate* = 4.

Lookup	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00
Return	0.00	0.25	0.38	0.50	0.75	0.10	0.08	0.70

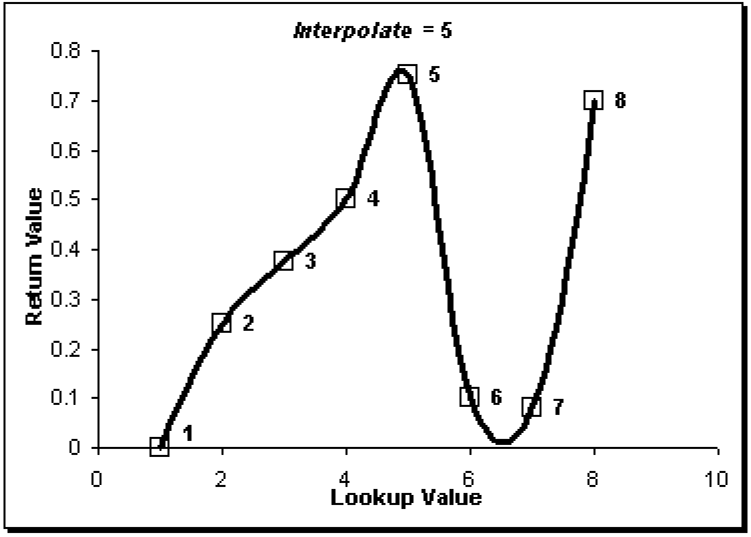


Interpolate = 5: Double Parabolic Piecewise Curve Interpolation Example

The example below shows a graph of values returned by THLOOKUP for *Interpolate* = 5.

- For the lookup value = 3.5, the left curve is drawn through the points 2, 3 and 4, while the right curve is drawn through the points 3, 4 and 5.
- For the lookup value = 1.5, only the curve drawn through points 1, 2 and 3 is used.

Lookup	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00
Return	0.00	0.25	0.38	0.50	0.75	0.10	0.08	0.70

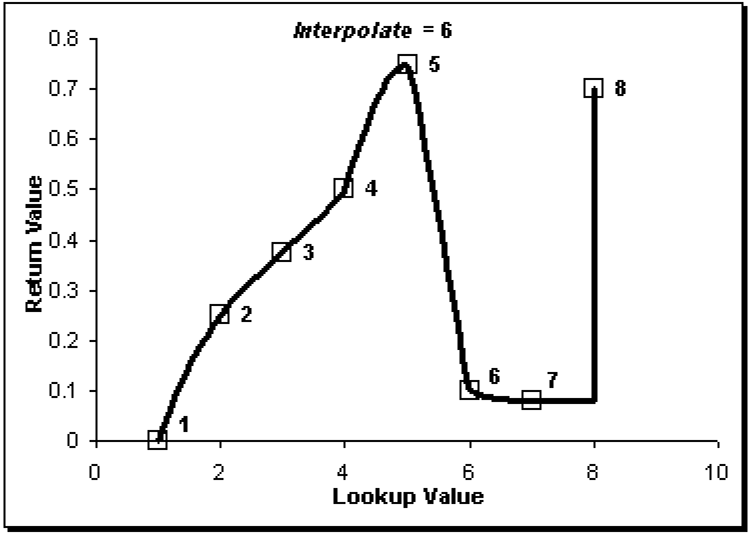


Interpolate = 6: Double Hyperbolic Piecewise Curve Interpolation Example

The example below shows a graph of values returned by THLOOKUP for *Interpolate* = 6.

- For the lookup value = 3.5, the left curve is drawn through the points 2, 3 and 4, while the right curve is drawn through the points 3, 4 and 5.
- For the lookup value = 1.5, only the curve drawn through points 1, 2 and 3 is used.
- 3-point hyperbolic curves are used in the following segments: (1,2,3), (2,3,4), (3,4,5) and (5,6,7)
- The constant return values are used in segments: (4,5,6) and (6,7,8).

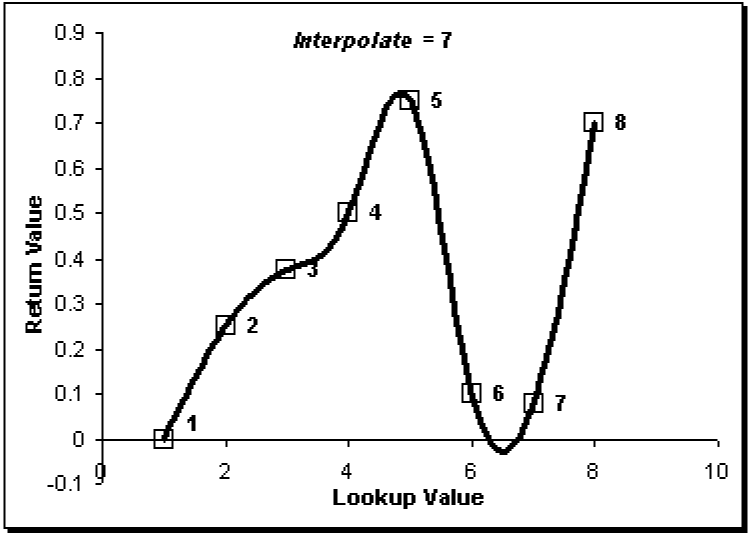
Lookup	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00
Return	0.00	0.25	0.38	0.50	0.75	0.10	0.08	0.70



Interpolate = 7: Cubic Spline Curve Interpolation Example

The example below shows a graph of values returned by THLOOKUP for *Interpolate* = 7.

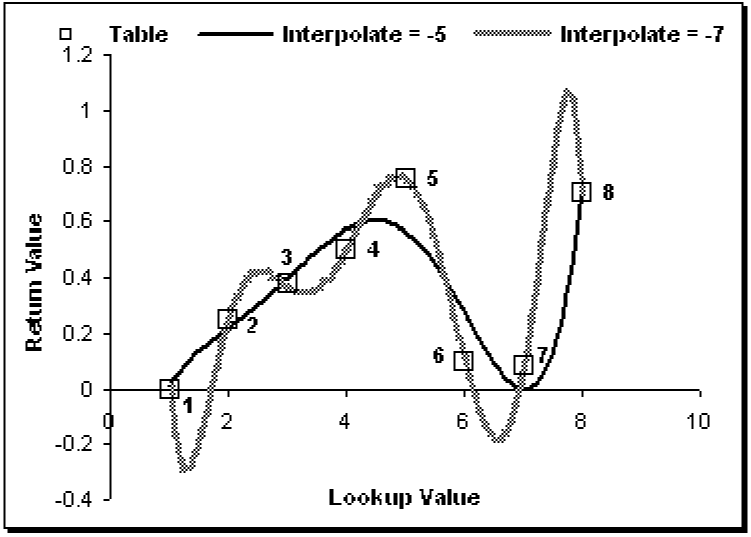
Lookup	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00
Return	0.00	0.25	0.38	0.50	0.75	0.10	0.08	0.70



Interpolate = -1 to -20: Polynomial Curve Interpolation Example

The example below shows graphs of values returned by THLOOKUP for *Interpolate* = -5 and -7.

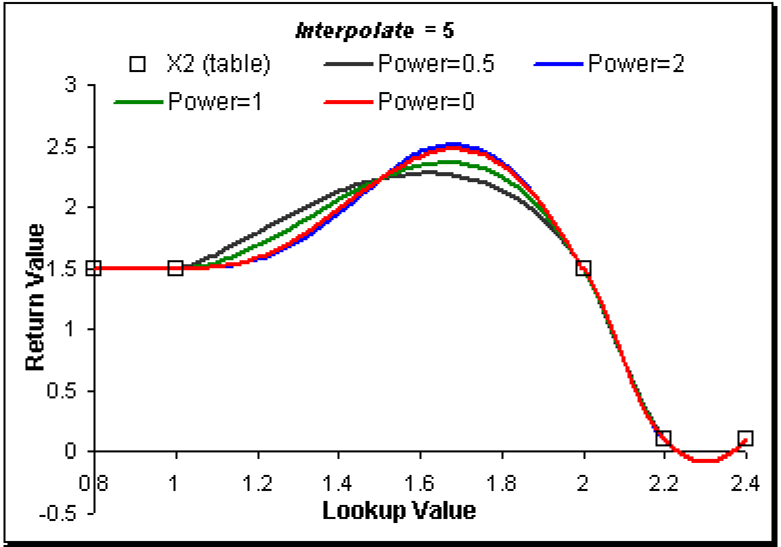
Lookup	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00
Return	0.00	0.25	0.38	0.50	0.75	0.10	0.08	0.70

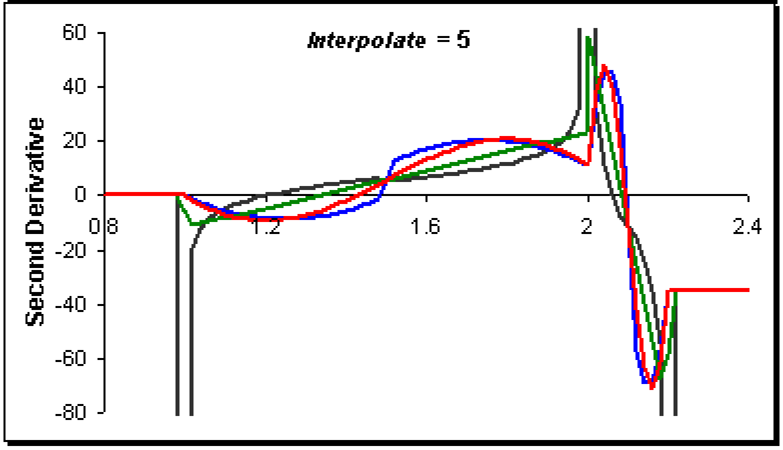


Power Examples

The top diagram in the example below shows graphs of values returned by THLOOKUP for ***Interpolate* = 5** and ***Power*** values of **0**, **0.5**, **1** and **2**. The bottom diagram shows how the second derivative curves depend on *Power*.

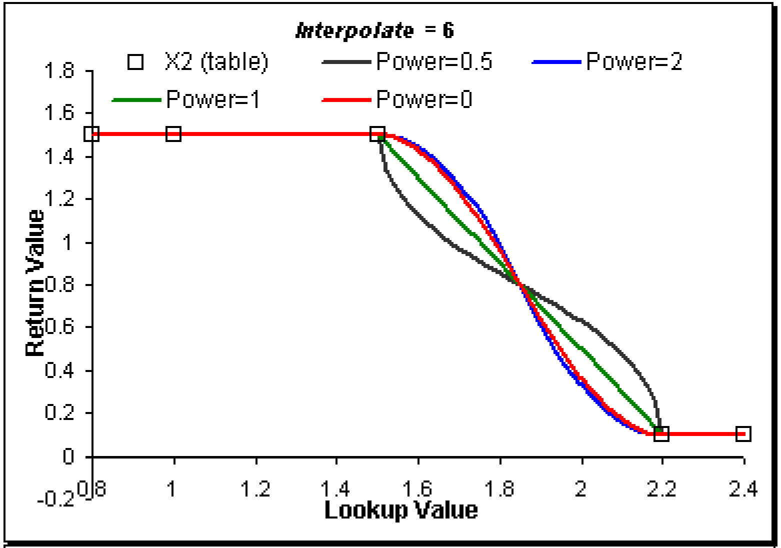
Lookup	0.8	1	2	2.2	2.4
Return	1.5	1.5	1.5	0.1	0.1

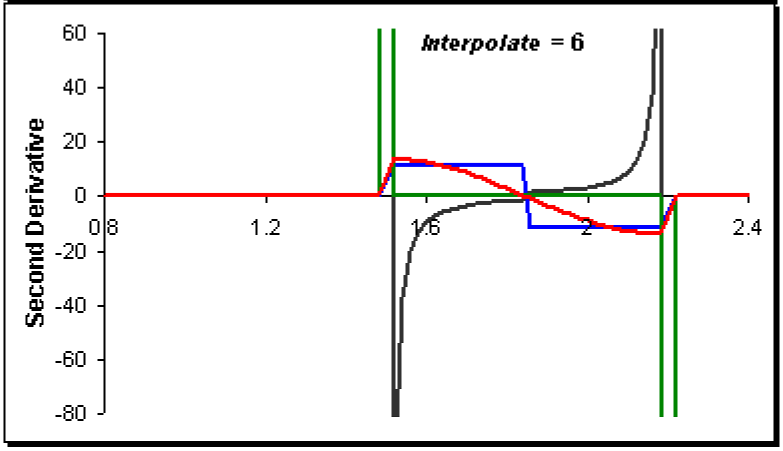




The top diagram in the example below shows graphs of values returned by THLOOKUP for ***Interpolate* = 6** and ***Power*** values of **0**, **0.5**, **1** and **2**. The bottom diagram shows how the second derivative curves depend on *Power*.

Lookup	0.8	1	1.5	2.2	2.4
Return	1.5	1.5	1.5	0.1	0.1





Missing_pts **and** ***Extrapolate*** **and Examples**

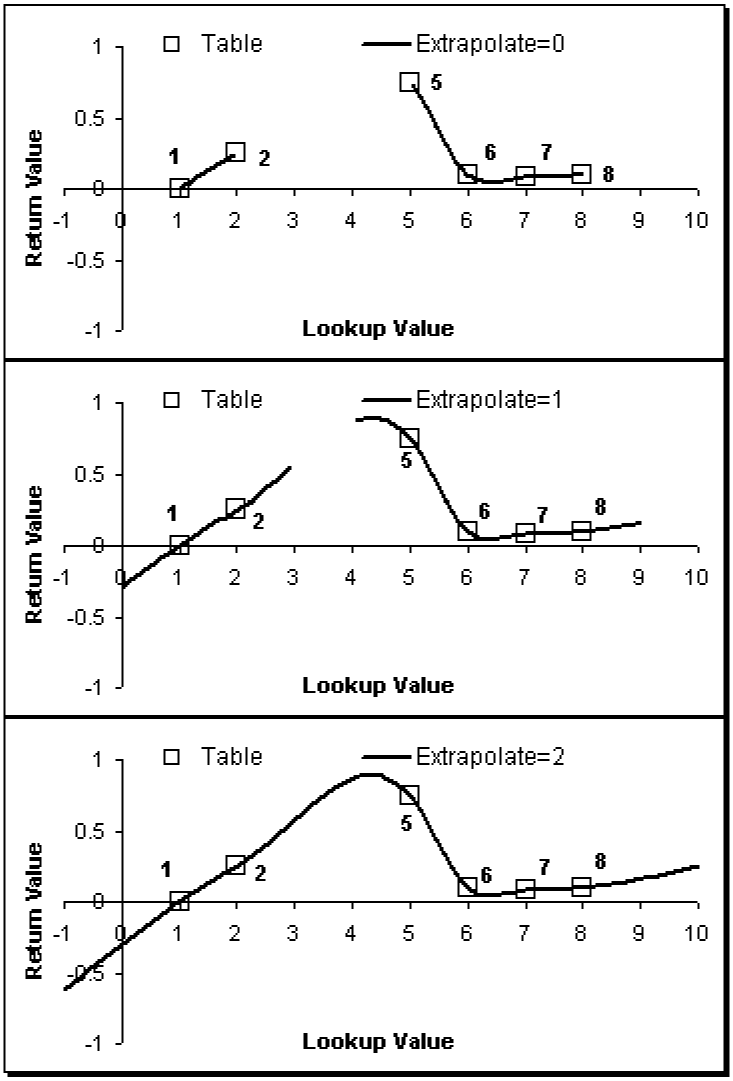
The following examples are available for the *Missing_pts* and *Extrapolate* parameters:

- For One Lookup Variable (TVLOOKUP & THLOOKUP)
- For Two Lookup Variables (T2LOOKUP)
- For Three Lookup Variables (T3LOOKUP)

Missing_pts **and** ***Extrapolate*** **for One Lookup Variable (TVLOOKUP and THLOOKUP)**

- For functions that use one lookup variable (TVLOOKUP and THLOOKUP), it is relatively simple to predict where they will return an interpolated value and where they will return #N/A, depending on the missing lookup/return points in the table and the value of the *Extrapolate* parameter. This is demonstrated in the example below.
- You can ensure that an interpolated value is returned for any lookup value between the minimum and the maximum table lookup values by setting *Extrapolate* = -1. That way the extrapolation interval will be the same size as the interval between the minimum and the maximum lookup values in the table.

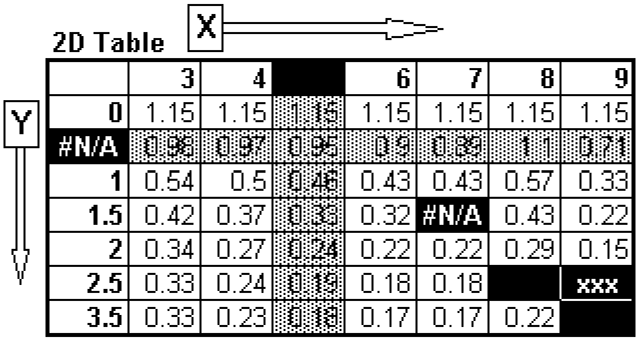
Lookup	1.0	2.0		4.0	5.0	6.0	7.0	8.0
Return	0.00	0.25		#N/A	0.75	0.10	0.08	0.10



The three diagrams in the above example show graphs of values returned by THLOOKUP for *Interpolate* = 5 and ***Extrapolate*** = **0**, **1** and **2**. The missing and invalid cells in the table above the diagrams are shown on the shaded background.

Missing_pts and *Extrapolate* for Two Lookup Variables (T2LOOKUP)

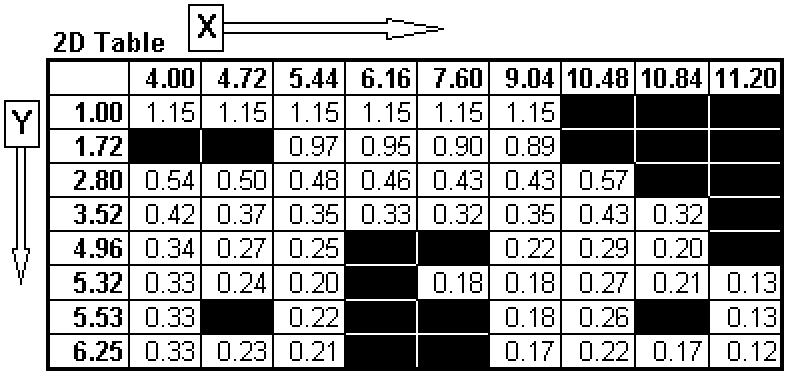
- For the T2LOOKUP function, which uses two lookup variables (X and Y), the shape and size of the **valid area** is determined by the missing points in the 2D lookup table and the values of the *X_extrapolate* and *Y_extrapolate* parameters. Valid area is a 2D region in X-Y space in which T2LOOKUP will return interpolated values. If a X-Y lookup point falls outside the valid area, T2LOOKUP will return #N/A.
- The example below shows a 2D table with empty and invalid cells on a dark background. Note that if an empty or invalid cell is located in either X-axis or Y-axis of the table, it will have the same effect as if the whole column (for X-axis) or row (for Y-axis) of cells in the data area was empty. Therefore, the cells with a shaded background in the table below are also regarded by T2LOOKUP as missing.



2D Table X Y

	3	4		6	7	8	9
0	1.15	1.15	1.15	1.15	1.15	1.15	1.15
#N/A	0.96	0.97	0.95	0.9	0.89	1.1	0.71
1	0.54	0.5	0.46	0.43	0.43	0.57	0.33
1.5	0.42	0.37	0.33	0.32	#N/A	0.43	0.22
2	0.34	0.27	0.24	0.22	0.22	0.29	0.15
2.5	0.33	0.24	0.19	0.18	0.18		xxx
3.5	0.33	0.23	0.18	0.17	0.17	0.22	

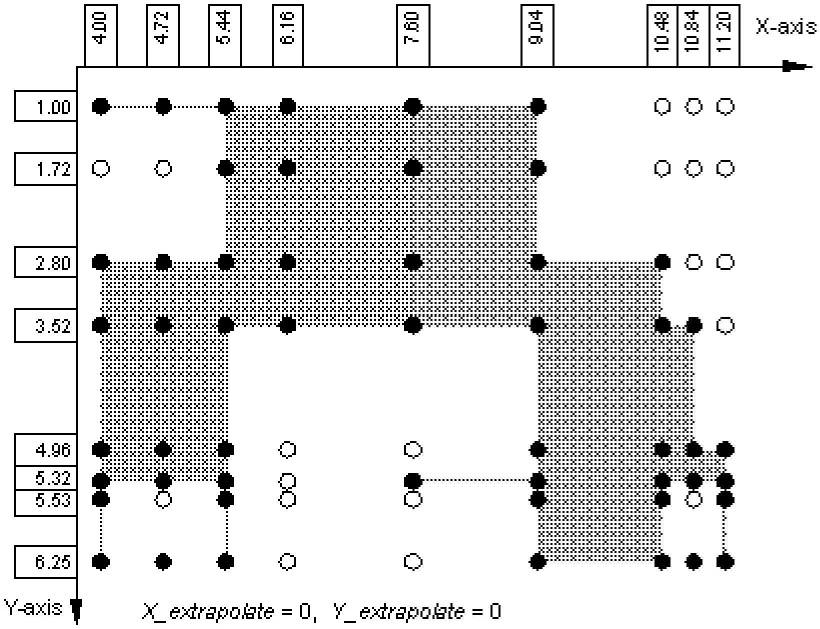
- The shape and size of the valid X-Y area (the one in which T2LOOKUP will return interpolated values) depends on the missing points in the 2D lookup table and the values of the ***X_extrapolate*** and ***Y_extrapolate*** parameters. This is demonstrated in the example below, where the top figure shows the contents of a 2D lookup table with missing values (on a dark background). The two figures below the table demonstrate how the valid X-Y area depends on the values of *X_extrapolate* and *Y_extrapolate* parameters.



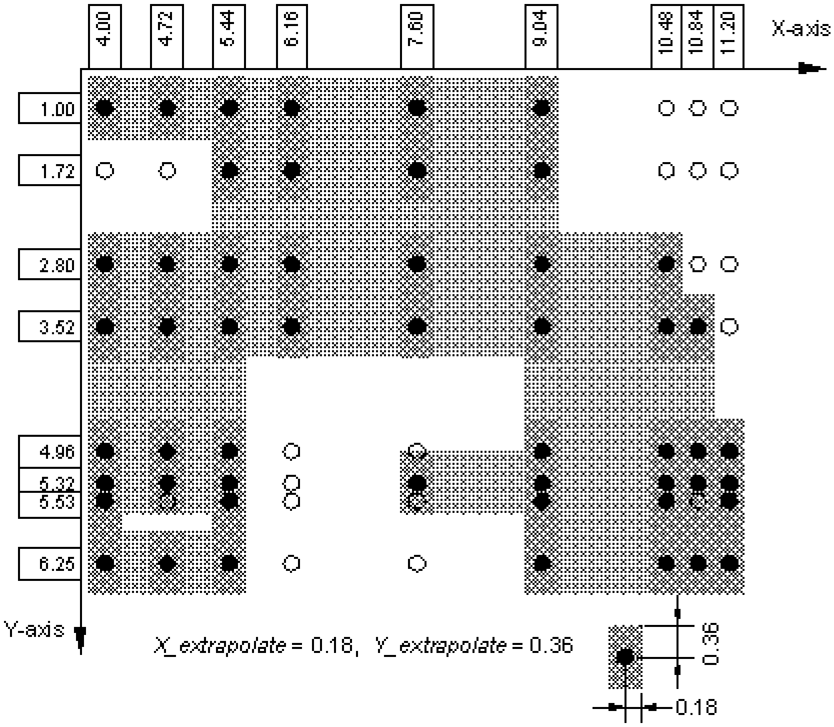
2D Table X Y

	4.00	4.72	5.44	6.16	7.60	9.04	10.48	10.84	11.20
1.00	1.15	1.15	1.15	1.15	1.15	1.15			
1.72			0.97	0.95	0.90	0.89			
2.80	0.54	0.50	0.48	0.46	0.43	0.43	0.57		
3.52	0.42	0.37	0.35	0.33	0.32	0.35	0.43	0.32	
4.96	0.34	0.27	0.25			0.22	0.29	0.20	
5.32	0.33	0.24	0.20		0.18	0.18	0.27	0.21	0.13
5.53	0.33		0.22			0.18	0.26		0.13
6.25	0.33	0.23	0.21			0.17	0.22	0.17	0.12

An example of a 2D lookup table with missing values.



A diagram showing the valid X-Y area (shaded) for the above table, for *X_extrapolate* = 0 and *Y_extrapolate* = 0. If a X-Y lookup point falls outside the valid area, T2LOOKUP will return #N/A. The valid table points are marked with ●, while the missing points are marked with ○.

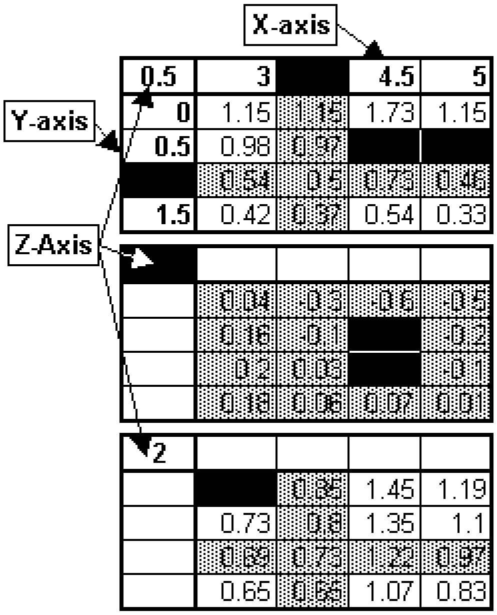


A diagram showing the valid X-Y area (shaded) for the above table, for *X_extrapolate* = 0.18 and *Y_extrapolate* = 0.36. If a X-Y lookup point falls outside the valid area, T2LOOKUP will return #N/A. The valid table points are marked with ●, while the missing points are marked with ○.

- You can ensure that an interpolated value is returned for any X and Y lookup values that lie between the minimum and the maximum table axis values (Xmin < X < Xmax; Ymin < Y < Ymax) by setting *X_extrapolate* = -1 and *Y_extrapolate* = -1. That way the X and Y extrapolation intervals will be the same size as the intervals between the minimum and the maximum X-axis and Y-axis values in the table.

***Missing_pts* and *Extrapolate* for Three Lookup Variables (T3LOOKUP)**

- For the T3LOOKUP function, which uses three lookup variables (X, Y and Z), the shape and size of the **valid region** is determined by the missing points in the 3D lookup table and the values of the *X_extrapolate*, *Y_extrapolate* and *Z_extrapolate* parameters. Valid region is a 3D region in X-Y-Z space in which T3LOOKUP will return interpolated values. If a X-Y-Z lookup point falls outside the valid region, T3LOOKUP will return #N/A.
- The example below shows a 3D table with empty and invalid cells on a dark background. Note that if an empty or invalid cell is located in the X-axis, Y-axis or Z-axis of the table, it will have the same effect as if the whole column (for X-axis) or row (for Y-axis) or 2D table (for Z-axis) of cells in the data area was empty. Therefore, the cells with a shaded background in the table below are also regarded by T3LOOKUP as missing.


X-axis
Y-axis
Z-Axis

0.5	3		4.5	5
0	1.15	1.15	1.73	1.15
0.5	0.98	0.97		
	0.54	0.5	0.73	0.46
1.5	0.42	0.37	0.54	0.33

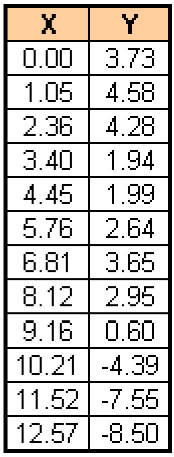
	0.04	-0.3	-0.6	-0.5
	0.16	-0.1		-0.2
	0.2	0.03		-0.1
	0.18	0.06	0.07	0.01

2				
		0.85	1.45	1.19
	0.73	0.8	1.35	1.1
	0.69	0.73	1.22	0.97
	0.65	0.55	1.07	0.83

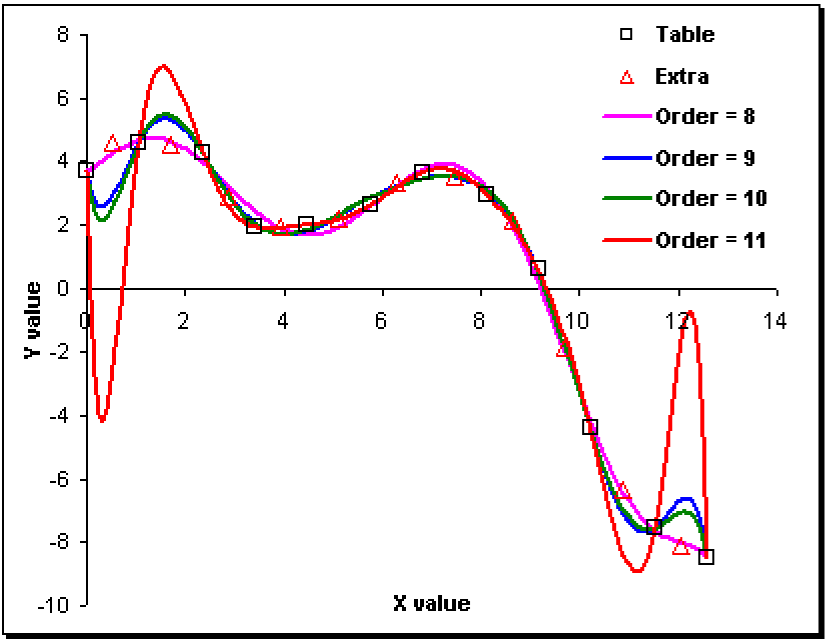
- The shape and size of the valid X-Y-Z region (the one in which T3LOOKUP will return interpolated values) depends on the missing points in the 3D lookup table and the values of the ***X_extrapolate***, ***Y_extrapolate*** and ***Z_extrapolate*** parameters. This cannot be easily demonstrated because the valid region is three-dimensional. However, you can get a pretty good idea about how it is determined by studying the above 2D example for T2LOOKUP.
- You can ensure that an interpolated value is returned for any X, Y and Z lookup values that lie between the minimum and the maximum table axis values (Xmin < X < Xmax; Ymin < Y < Ymax; Zmin < Z < Zmax) by setting *X_extrapolate* = -1, *Y_extrapolate* = -1 and *Z_extrapolate* = -1. That way the X, Y and Z extrapolation intervals will be the same size as the intervals between the minimum and the maximum X-axis, Y-axis and Z-axis values in the table.

Smooth_R2 Example

The example below demonstrates the use of extra in-between points to easily determine the polynomial curve that best approximates a set of data points defined by a table of X and Y values.

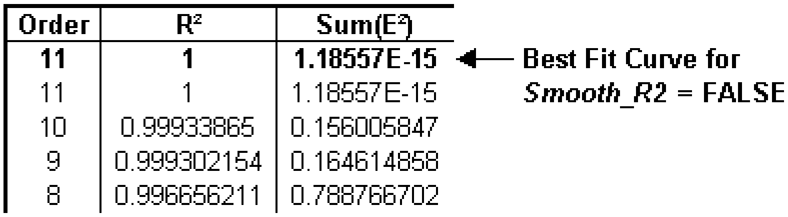


X	Y
0.00	3.73
1.05	4.58
2.36	4.28
3.40	1.94
4.45	1.99
5.76	2.64
6.81	3.65
8.12	2.95
9.16	0.60
10.21	-4.39
11.52	-7.55
12.57	-8.50



The above table with 12 X-Y points (named “Table”) is used by TVPOLYDATA to calculate the polynomial curve coefficients and the values of R^2 and Sum(E^2). The maximum possible order is 11 (max order = number of points - 1). The array formula and the first 3 columns and 6 rows of values returned by TVPOLYDATA for *Smooth_R2* = FALSE are shown below.

```
{=TVPOLYDATA(Table,"X","Y ",11,FALSE)}
```

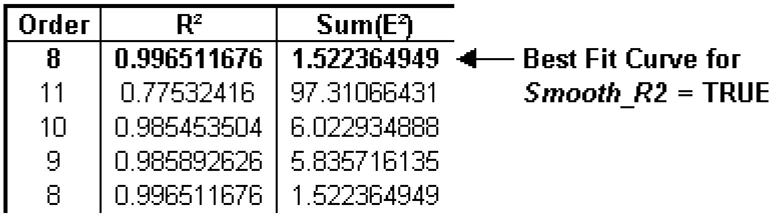


Order	R^2	Sum(E^2)
11	**1**	**1.18557E-15**
11	1	1.18557E-15
10	0.99933865	0.156005847
9	0.999302154	0.164614858
8	0.996656211	0.788766702

Best Fit Curve for *Smooth_R2* = FALSE

The array formula and the first 3 columns and 6 rows of values returned by TVPOLYDATA for *Smooth_R2* = TRUE are shown below.

```
{=TVPOLYDATA(Table,"X ","Y ",11,TRUE)}
```



Order	R^2	Sum(E^2)
8	**0.996511676**	**1.522364949**
11	0.77532416	97.31066431
10	0.985453504	6.022934888
9	0.985892626	5.835716135
8	0.996511676	1.522364949

Best Fit Curve for *Smooth_R2* = TRUE

Example Workbooks

TriLookup Interactive Examples

This Excel workbook is provided as a part of TriLookup documentation. It contains interactive examples that demonstrate the use and capabilities of different TriLookup functions. The interactive examples also show line and surface graphs of values returned by the functions.

The worksheets in this workbook are protected, so that you cannot accidentally change the contents of the cells with formulas. Only the following cells can be edited:

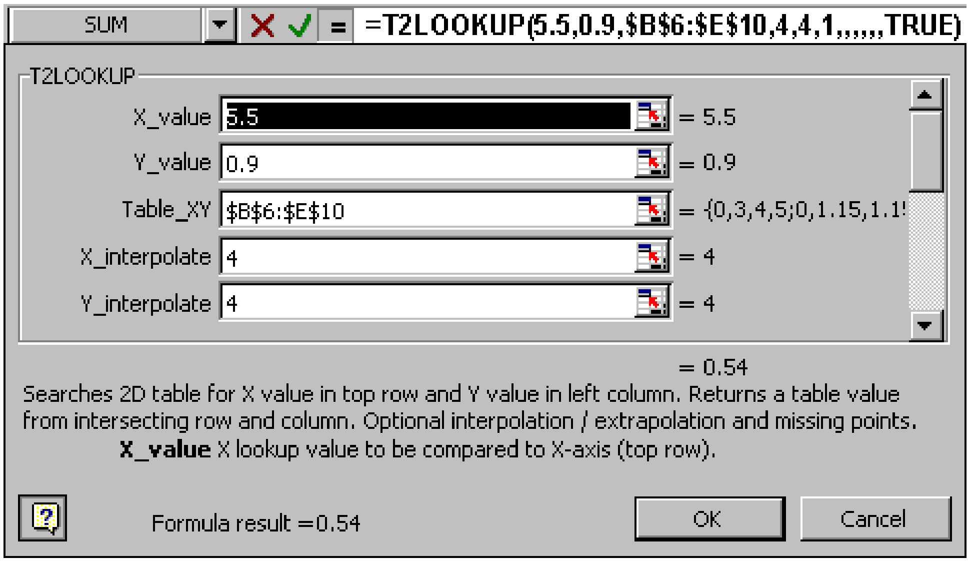
- The cells in the Lookup Tables;
- The cells with a colored background in the Parameter Tables.

If you wish to edit any of the other cells, or change anything else on the worksheets, you can do that by first unprotecting the worksheet by clicking on **Tools | Protection | Unprotect Sheet**.

If you wish to examine or change parameter values in a cell that contains a TriLookup function, you can do that either manually by editing the cell formula text, or interactively by selecting the cell and then clicking on the **Paste Function** button *fx*. For example, if a cell contains the following formula:

`=T2LOOKUP(5.5,0.9,$B$6:$E$10,4,4,1,,,,,,TRUE)`

then selecting the cell and clicking on the **Paste Function** button *fx* will invoke the **Formula Palette** dialog box with the current values of the parameters already filled in:



=T2LOOKUP(5.5,0.9,$B$6:$E$10,4,4,1,,,,,,TRUE)

T2LOOKUP

X_value	5.5	= 5.5
Y_value	0.9	= 0.9
Table_XY	$B$6:$E$10	= {0,3,4,5;0,1.15,1.1
X_interpolate	4	= 4
Y_interpolate	4	= 4

= 0.54

Searches 2D table for X value in top row and Y value in left column. Returns a table value from intersecting row and column. Optional interpolation / extrapolation and missing points.

X_value X lookup value to be compared to X-axis (top row).

Formula result =0.54

When opened, this workbook sets Excel's **Calculation** option to **Manual**. This has been done because some of the example worksheets can take several seconds to recalculate. It is recommended that you recalculate the sheet after completing any changes by clicking on the [**Recalculate Sheet**] button, rather than pressing <F9> or <Shift><F9>. Using the [**Recalculate Sheet**] button will ensure that diagram captions are updated and that any #N/A points are removed from the line diagrams.

When you open this example workbook by clicking on **Help | TriLookup Help | Example Workbooks | Interactive**, it will be opened in **read-only** mode. If you wish to modify it, you should save it under a different name.

The VBA code used in this workbook to automate certain procedures (e.g., restore tables , set diagram titles, etc.) is not protected, and can freely be copied or modified to suit any purpose.

This example workbook contains the following 4 worksheets:

1. 'TVLOOKUP & TVLKP'
2. 'T2LOOKUP & T2LKP'
3. 'T3LOOKUP & T3LKP'
4. 'TVPOLYDATA & TVPOLY'

TVLOOKUP & TVLKP Interactive Example Worksheet

The large combo box in the top left corner of worksheet offers a choice between using the more complex **TVLOOKUP** or the simplified **TVLKP** function. When you switch from one function to the other, all references to the function in the worksheet, as well as the lists of parameters, are automatically updated. Note that in the remainder of the text below, **TVLOOKUP** stands for either **TVLOOKUP** or **TVLKP**.

The **Parameters Table** in the top left corner of this worksheet allows you to interactively change the parameters of the TVLOOKUP function by modifying the values in the cells with a colored background. After you are done, click on the small [**Calc**] button in the top left corner to recalculate and display the new TVLOOKUP Value in the large merged cell at the top of the table. The **Cell Formula** cell shows the formula used to return the value above it.

Note that the parameters in the **Parameter Table** that have a yellow background color also affect the diagram.

The lookup table for this example is given under the title **Table**. It is a 2D multi column table with column titles in the topmost row of the table. You can edit the column titles and data area cells in order to investigate how TVLOOKUP works with different data sets. You can at any point restore the original data set by clicking on the [**Restore Table**] button. Note that **Restore Table** won't work properly if you have inserted or deleted any rows or columns in the table.

The table titled **TVLOOKUP Returned Values for the Diagrams** contains V(x) values returned by TVLOOKUP an array of closely spaced lookup values. It is used to plot the diagram shown at the top of the worksheet. The diagram shows five different curves of TVLOOKUP returned values for five different values of the ***Interpolate*** parameter. You can change the values for *Interpolate* used on the diagram by editing the values in the topmost row of the **TVLOOKUP Returned Values for the Diagrams** table. You can also select different lookup column and return column by changing the ***Lookup_title*** and ***Return_title*** parameter values in **Parameters Table**. The little squares on the diagram indicate the coordinates of the all the points defined by pairs of values in the lookup column and return column of the lookup table.

The **Diagram Settings** combo box contains two options: **Use Original Limits** and **Extrapolated Limits**. When **Use Original Limits** is selected, the minimum and maximum limits for the lookup value on the diagram are the same as the minimum and maximum values in the lookup column. If **Extrapolated Limits** is chosen, the diagram limits are extended to also show the extrapolated values returned by TVLOOKUP. How far the limits will be extended depends on the *Extrapolate* value in the **Parameters Table**

The **#N/A Points** combo box contains two options: **Hide #N/A Points** and **Don't Hide #N/A Points**. When **Hide #N/A Points** is selected, all #N/A points caused by missing or invalid table values are removed from the line diagram. On a slow computer the process of removing the #N/A points can take a long time. In that case you should select **Don't Hide #N/A Points**.

After changing any of the parameters, click on the [**Recalculate Sheet**] button to update all tables and diagrams on the worksheet. This is necessary because the Calculation option for this workbook is set to **Manual**.

T2LOOKUP & T2LKP Interactive Example Worksheet

The large combo box in the top left corner of worksheet offers a choice between using the more complex **T2LOOKUP** or the simplified **T2LKP** function. When you switch from one function to the other, all references to the function in the worksheet, as well as the lists of parameters, are automatically updated. Note that in the remainder of the text below, **T2LOOKUP** stands for either **T2LOOKUP** or **T2LKP**.

The **Parameters Table** in the top left corner of this worksheet allows you to interactively change the parameters of the T2LOOKUP function by modifying the values in the cells with a colored background. After you are done, click on the small [**Calc**] button in the top left corner to recalculate and display the new T2LOOKUP Value in the large merged cell at the top of the table. The **Cell Formula** cell shows the formula used to return the value above it.

Note that the parameters in the **Parameter Table** that have a yellow background color also affect the diagrams.

The lookup table for this example is given under the title "Table". It is a 2D (X-Y) table. You can edit its X-axis, Y-axis and data area cells in order to investigate how T2LOOKUP works on different data sets. You can at any point restore the original data set by clicking on the [**Restore Table**] button. Note that **Restore Table** won't work properly if you have inserted or deleted any rows or columns in the table.

The table titled **T2LOOKUP Returned Values for the Diagrams** contains V(x,y) values returned by T2LOOKUP for an array of closely spaced X and Y values. It is used to plot the two **diagrams** shown on the right hand side of this worksheet. The line diagram on top shows a series of curves of T2LOOKUP returned values. It also shows the V(x,y) table values of the all the X-Y points given in the lookup table. You can chose which one of the two independent variables (X or Y) will be plotted on the horizontal axis (**X/Y=Variable**) and which variable will be incremented from one curve to the next (**X/Y=Discrete**) by picking from the left combo box under the **Diagram Settings** title. Note that the surface chart below shows the “**Variable”** variable (X or Y) on the two horizontal axes, and the return value V(x,y) on the vertical axis.

The third diagram on this worksheet (the one on the left) shows a surface chart of the all the V(x,y) points given in the lookup table, with X and Y values on the two horizontal axes, and the return value (V) on the vertical axis.

The right combo box under the **Diagram Settings** title contains two options: **Use Original Limits** and **Extrapolated Limits**. When **Use Original Limits** is selected, the minimum and maximum limits for X and Y variables on the diagrams are the same as the minimum and maximum values in the X-axis and Y-axis in the lookup table. If **Extrapolated Limits** is chosen, the diagram limits are extended to also show the extrapolated values returned by T2LOOKUP. How far the limits will be extended depends on the *X_extrapolate* and *Y_extrapolate* values in the **Parameters Table**.

The **#N/A Points** combo box contains two options: **Hide #N/A Points** and **Don’t Hide #N/A Points**. When **Hide #N/A Points** is selected, all #N/A points caused by missing or invalid table values are removed from the line diagram. On a slow computer the process of removing the #N/A points can take a long time. In that case you should select **Don’t Hide #N/A Points**.

In order to examine the two surface diagrams from any angle, you can use the horizontal and vertical **scroll bars** in the top-right corner of the chart on the left to change their rotation and elevation properties.

After changing any of the parameters, click on the [**Recalculate Sheet**] button to update all tables and diagrams on the worksheet. This is necessary because the Calculation option for this workbook is set to **Manual**.

T3LOOKUP & T3LKP Interactive Example Worksheet

The large combo box in the top left corner of the worksheet offers a choice between using the more complex **T3LOOKUP** or the simplified **T3LKP** function. When you switch from one function to the other, all references to the function in the worksheet, as well as the lists of parameters, are automatically updated. Note that in the remainder of the text below, **T3LOOKUP** stands for either **T3LOOKUP** or **T3LKP**.

The **Parameters Table** in the top left corner of this worksheet allows you to interactively change the parameters of the T3LOOKUP function by modifying the values in the cells with a colored background. After you are done, click on the small [**Calc**] button in the top left corner to recalculate and display the new T3LOOKUP Value in the large merged cell at the top of the table. The **Cell Formula** cell shows the formula used to return the value above it.

Note that the parameters in the **Parameter Table** that have a yellow background color also affect the diagrams.

The lookup table for this example is given under the title **Table, TableMA**. It is a 3D (X-Y-Z) table that contains multiple 2D (X-Y for Z=const) tables. You can edit its X-axis, Y-axis, Z-axis and data area cells in order to investigate how T3LOOKUP works on different data sets. You can at any point restore the original data set by clicking on the [**Restore Table**] button. Note that **Restore Table** won't work properly if you have inserted or deleted any rows or columns in the table.

The combo box to the right of the [**Restore Table**] button lets you select between the **Single Area Table** and **Multi Area Table** mode of specifying the *Table_XYZ* parameter to be used throughout this worksheet. The sheet range name **Table** refers to a single area range containing the whole 3D (X-Y-Z) lookup table, while the sheet range name **TableMA** refers to a multiple area range containing an array of references to all individual 2D (X-Y, for Z=const) tables that are a part of the 3D lookup table. Note that the T3LKP function can only use the Multiple Area Table.

The table titled **T3LOOKUP Returned Values for the Diagrams** contains V(x,y,z) values returned by T3LOOKUP for an array of closely spaced X, Y and Z values. It is used to plot the two diagrams shown on this worksheet. The **line diagram** on top shows a series of curves of T3LOOKUP returned values. You can chose which one of the three independent variables (X, Y or Z) will be plotted on the horizontal axis (**X/Y/Z=Variable**), which variable will be incremented from one curve to the next (**X/Y/Z=Discrete**) and which variable will be kept constant (**X/Y/Z=Constant**) by picking from the left combo box under the **Diagram Settings** title. The same settings will also apply to the surface chart below, which shows the **Variable** and **Discrete** variables on the two horizontal axes and the return value V(x,y,z) on the vertical axis, while keeping the **Constant** variable unchanged. The Constant variable will have the value specified in the *X_value*, *Y_value* or *Z_value* cell in the **Parameters Table** (depending on which one is set as constant).

The right combo box under the **Diagram Settings** title contains two options: **Use Original Limits** and **Extrapolated Limits**. When **Use Original Limits** is selected, the minimum and maximum limits for X, Y and Z variables on the diagrams are the same as the minimum and maximum values in the X-axis, Y-axis, Z-axis in the lookup table. If **Extrapolated Limits** is chosen, the diagram limits are extended to also show the extrapolated values returned by T3LOOKUP. How far the limits will be extended depends on the *X_extrapolate*, *Y_extrapolate* and *Z_extrapolate* values in the **Parameters Table**.

The **#N/A Points** combo box contains two options: **Hide #N/A Points** and **Don't Hide #N/A Points**. When **Hide #N/A Points** is selected, all #N/A points caused by missing or invalid table values are removed from the line diagram. On a slow computer the process of removing the #N/A points can take a long time. In that case you should select **Don't Hide #N/A Points**.

In order to examine the surface diagram from any angle, you can use the horizontal and vertical **scroll bars** in its top-right corner to change its rotation and elevation properties.

After changing any of the parameters, click on the [**Recalculate Sheet**] button to update all tables and diagrams on the worksheet. This is necessary because the Calculation option for this workbook is set to **Manual**.

You can click on the [**Animate**] button, located between the two diagrams, to see how the returned values (and diagrams) change when the variable selected as **X/Y/Z=Discrete** is incremented from its minimum to its maximum limit. The size of the increment depends on the limits and the number of animation steps, which can be chosen through the **Step** cell to the right of the [**Animate**] button.

Note: If you have a slow computer, the animation may take a long time to complete. You can make it shorter by reducing the number of steps, by using linear interpolation (by choosing *X/Y/Z_interpolate* = 4) and by setting *Missing_pts* = FALSE.
In order to interrupt the animation, press <Ctrl><Break> at any point and then click on the [**End**] button in the dialog box.

TVPOLYDATA & TPOLY Interactive Example Worksheet

The **TVPOLYDATA Parameters Table** in the top left corner of this worksheet allows you to interactively change the parameters of the **TVPOLYDATA** function by modifying the values in the cells with the yellow background. When you are done, click on the [**Calc**] button to recalculate and display the first 2 rows and 7 columns of the array returned by TVPOLYDATA. The first row contains the column headers and the second row holds the values for the best fit curve (the one with the highest R^2). The large merged cell at the top of the table is reserved for the display of a detailed text error message in case **TVPOLYDATA** returns an error.

The **Cell Formula** cell shows the array formula used to return the values above it. The **TOPLY(...)** and **Formula** cells contain pasted Values of the TOPLY(...) and Formula cells above.

Note that the parameters in **TVPOLYDATA Parameter Table** with a yellow background color also affect the curves shown in the diagram.

The **TPOLY Parameters Table** below the **TVPOLYDATA Parameter Table** allows you to interactively change the parameters of the **TPOLY** function by modifying the values in the cells with the colored background. When you are done, click on the [**Calc**] button to recalculate and display the value returned by the **TPOLY** function. Note that the formula for calculating the **TPOLY** value shown in this table is set up in such a way that the polynomial coefficients are retrieved from the **TVPOLYDATA Returned Values (Array Formula)**, from the row that that has the same **Order** as the *Order* parameter specified in the **TPOLY Parameters Table**.

The lookup table for this example is given under the title **Table**. It is a 50-row 8-column multi column table, with column titles in the topmost row of the table. You can edit the column titles and data area cells in order to investigate how TVPOLYDATA works on different data sets. You can at any point restore the original data set by clicking on the [**Restore Table**] button. Note that **Restore Table** won't work properly if you have inserted or deleted any rows or columns in the table.

The [**Change # of Points to:**] button, and the value in the yellow background cell to the right, allow you to easily change the number of X-Y points in the lookup table to anywhere between 2 and 49. The extra return rows are commented out and hidden. Note that when you set the number of points to less than 49, you must set the *Missing_pts* parameter in the **TVPOLYDATA Parameters Table** to TRUE.

The table titled **TVPOLYDATA Returned Values (Array Formula)** is a 22-row by 26-column range of cells that contains TVPOLYDATA function entered as an array formula. It shows all the values returned by TVPOLYDATA for a set of parameters given in the **TVPOLYDATA Parameters Table**. The polynomial coefficients from this table are used to plot the diagram at the top of this worksheet. The diagram shows five polynomial curves - four with the highest order values returned by TVPOLYDATA, plus the one determined to be the **best fit curve**. You can easily change the order of the displayed curves by changing the *Max_order* parameter in the **TVPOLYDATA Parameters Table**. You can also select different lookup column and return column by changing the *Lookup_title* and *Return_title* values in **TVPOLYDATA Parameters Table**.

The smaller diagram below shows a plot of **R^2** values versus the polynomial **Order** from the data in the **TVPOLYDATA Returned Values (Array Formula)** table.

The **Forecast Forward** and **Forecast Back** values above the main diagram set the lower and upper limits for the X variable when calculating and displaying the polynomial curves. They determine how far to go beyond the minimum and maximum values in the lookup column of the lookup table.

After changing any of the parameters, click on the [**Recalculate Sheet**] button to update all tables and diagrams on the worksheet. This is necessary because the Calculation option for this workbook is set to **Manual**.

TriLookup Practical Examples

This Excel workbook is provided as a part of TriLookup documentation. It contains practical examples that demonstrate the use and capabilities of different TriLookup functions.

Note: The practical examples given in this workbook have been taken from reference literature for mechanical engineering. However, these examples were NOT meant to provide any useful information, but only to demonstrate the use TriLookup functions. Consequently, they should not be used for any other purpose.

Most of the examples in this workbook are set up in the following way. The table(s) on top contain 4 types of cells (see example below):

- Example No shading with black text – fixed labels;
- Example Shaded green with black text – lookup values that the user must type in;
- Example Shaded yellow with black text – lookup values that the user can either type in or pick from a drop-down list;
- Example No shading with blue text – values returned by a TriLookup function.

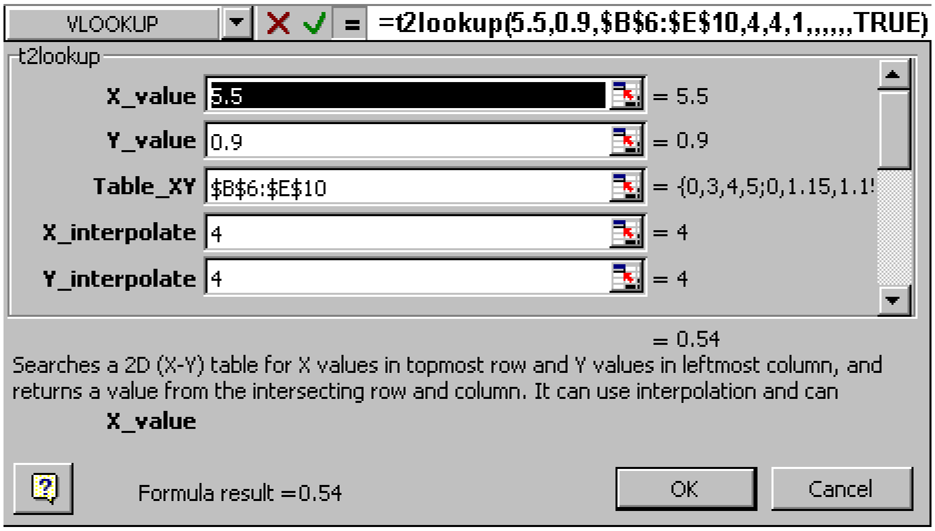
The large table below is the lookup table with data.

The worksheets in this workbook are NOT protected. When opened, this workbook sets Excel's **Calculation** option to **Automatic**.

If you wish to examine or change parameter values in a cell that contains a TriLookup function, you can do that either manually by editing the cell formula text, or interactively by selecting the cell and then clicking on the **Paste Function** button fx. For example, if a cell contains the following formula:

```
=T2LOOKUP(5.5,0.9,$B$6:$E$10,4,4,1,,,,,,TRUE)
```

then selecting the cell and clicking on the **Paste Function** button fx will invoke the **Formula Palette** dialog box with the current values of the parameters already filled in:



=t2lookup(5.5,0.9,$B$6:$E$10,4,4,1,,,,,,TRUE)

t2lookup

X_value	5.5	= 5.5
Y_value	0.9	= 0.9
Table_XY	$B$6:$E$10	= {0,3,4,5;0,1.15,1.1!
X_interpolate	4	= 4
Y_interpolate	4	= 4

= 0.54

Searches a 2D (X-Y) table for X values in topmost row and Y values in leftmost column, and returns a value from the intersecting row and column. It can use interpolation and can

X_value

Formula result =0.54

When you open this example workbook by clicking on **Help | TriLookup Help | Example Workbooks | Practical**, it will be opened in **read-only** mode. If you wish to modify it, you should save it under a different name.

The VBA code used in this workbook is not protected, and can freely be copied or modified to suit any purpose. The workbook contains two custom sheet functions in the VBA module **mCustomFunctions**: **GasEnthalpy** and **GasTemperature**. Both functions reference the lookup table ‘**EnthalpyTable**’ on the worksheet ‘**TVLOOKUP 2**’.

Glossary

Data Area

Data area is the region of the lookup table which contains the return values:

- For T2LOOKUP and T2LKP functions, the data area is located in the body of the 2D table, excluding the topmost row and the leftmost column.
- For T3LOOKUP and T3LKP functions, the data areas are located in the body of each component 2D table, excluding their topmost rows and leftmost columns.

Lookup Area

Lookup Area is the region of the lookup table which contains an array of values that are compared to the lookup value:

- For TVLOOKUP, TVLKP and TVPOLYDATA functions, the lookup area is the **Lookup Column**, with the title (in the topmost cell) equal to the *Lookup_title* parameter.
- For THLOOKUP, THLKP and THPOLYDATA functions, the lookup area is the **Lookup Row**, with the title (in the leftmost cell) equal to the *Lookup_title* parameter.
- For T2LOOKUP, T2LKP, T3LOOKUP and T3LKP functions, the lookup areas for X, Y and Z values are the **X-axis**, **Y-axis** and **Z-axis**, respectively.

Lookup Column

Lookup column is the column of the lookup table which contains an array of values that are compared to the lookup value in TVLOOKUP, TVLKP and TVPOLYDATA functions.

Which table column will be the lookup column is determined by the ***Lookup_title*** and ***Index_mode*** parameters:

- If the *Index_mode* parameter is omitted or it is set to FALSE, then the *Lookup_title* parameter has to match the title of any one of the columns in the lookup table (*Table_array*). Column titles are located in the topmost row of the lookup table.
- If *Index_mode* is set to TRUE, then the *Lookup_title* parameter specifies the lookup column index number (position of the lookup column in *Table_array*: 1 for the first column, 2 for the second column, etc.), and it has to be a whole number between 1 and the number of columns in the lookup table (*Table_array*). Note that in this case the column titles in the topmost row of *Table_array* are ignored.

Lookup Row

Lookup row is the row of the lookup table which contains an array of values that are compared to the lookup value in THLOOKUP, THLKP and THPOLYDATA functions.

Which table row will be the lookup row is determined by the ***Lookup_title*** and ***Index_mode*** parameters:

- If the *Index_mode* parameter is omitted or it is set to FALSE, then the *Lookup_title* parameter has to match the title of any one of the rows in the lookup table (*Table_array*). Row titles are located in the leftmost column of the lookup table.
- If *Index_mode* is set to TRUE, then the *Lookup_title* parameter specifies the lookup row index number (position of the lookup row in *Table_array*: 1 for the first row, 2 for the second row, etc.), and it has to be a whole number between 1 and the number of rows in the lookup table (*Table_array*). Note that in this case the row titles in the leftmost column of *Table_array* are ignored.

Multi Area Table

A 3D table in which all component 2D tables are specified as separate areas in a **multiple area range of cells.** The first 2D table is specified as the first area of the range and the subsequent ones are listed after it. When using a Multi Area Table, only the top-left cells need to be specified for the subsequent 2D tables and the values for *Table_Ygap* and *Table_Ysize* parameters are ignored.

When specifying a multiple area range as the *Table_XYZ* parameter, you must enclose it in parentheses. Otherwise, it will be interpreted as more than one parameter, which will cause an error.

Note: All component 2D tables must be located on a same worksheet.

Applies to T3LOOKUP and T3LKP ***Table_XYZ*** parameter, which specifies a 3D lookup table that contains multiple 2D tables. Each 2D table is a rectangular range of cells and corresponds to a different Z-axis value. All component 2D tables must be the same size in horizontal (X) and vertical (Y) direction as the first 2D table.

Note: The T3LKP function can only use multi area tables.

Return Column

Return column is the region of the lookup table which contains the return values in TVLOOKUP, TVLKP and TVPOLYDATA functions.

Which table column will be the return column is determined by the ***Return_title*** and ***Index_mode*** parameters:

- If the *Index_mode* parameter is omitted or it is set to FALSE, then the *Return_title* parameter has to match the title of any one of the columns in the lookup table (*Table_array*). Column titles are located in the topmost row of the lookup table.
- If *Index_mode* is set to TRUE, then the *Return_title* parameter specifies the return column index number (position of the return column in *Table_array*: 1 for the first column, 2 for the second column, etc.), and it has to be a whole number between 1 and the number of columns in the lookup table (*Table_array*). Note that in this case the column titles in the topmost row of *Table_array* are ignored.

Return Row

Return row is the region of the lookup table which contains the return values in THLOOKUP, THLKP and THPOLYDATA functions.

Which table row will be the return row is determined by the ***Return_title*** and ***Index_mode*** parameters:

- If the *Index_mode* parameter is omitted or it is set to FALSE, then the *Return_title* parameter has to match the title of any one of the rows in the lookup table (*Table_array*). Row titles are located in the leftmost column of the lookup table.
- If *Index_mode* is set to TRUE, then the *Return_title* parameter specifies the return row index number (position of the return row in *Table_array*: 1 for the first row, 2 for the second row, etc.), and it has to be a whole number between 1 and the number of rows in the lookup table (*Table_array*). Note that in this case the row titles in the leftmost column of *Table_array* are ignored.

Shareware

Shareware lets you try a program for a period of time before you buy it. Since you've tried a shareware program, you know whether it will meet your needs before you pay for it. If you use this program for a longer time than the specified trial period (30 days), you are expected to register it. A licensed version of this product includes the permanent right to use the product for an unlimited time. The licensed version also disables the registration screen when starting the program.

Single Area Table

A 3D table in which all component 2D tables are contained in a **single rectangular range of cells**, with the first 2D table on top and the subsequent ones below it. In order for the T3LOOKUP function to be able to differentiate between individual 2D tables, you must specify the correct values for ***Table_Ygap*** and ***Table_Ysize*** parameters.

Applies to T3LOOKUP ***Table_XYZ*** parameter, which specifies a 3D lookup table that contains multiple 2D tables. Each 2D table is a rectangular range of cells and corresponds to a different Z-axis value. All component 2D tables must be the same size in horizontal (X) and vertical (Y) direction as the first 2D table.

Note: The T3LKP function cannot use single area tables.

X-axis

X-axis is a row of X lookup values in a 2D (X-Y) or a 3D (X-Y-Z) lookup table. In a 2D lookup table X-axis is located in the topmost row of the lookup table, excluding the top left cell. In a 3D lookup table X-axis is located in topmost row of the first 2D table, excluding the top left cell.

Y-axis

Y-axis is a column of Y lookup values in a 2D (X-Y) or a 3D (X-Y-Z) lookup table. In a 2D lookup table Y-axis is located in the leftmost column, excluding the top left cell. In a 3D lookup table Y-axis is located in leftmost column of the first 2D table, excluding the top left cell.

Z-axis

Z-axis is an array Z lookup values in a 3D (X-Y-Z) lookup table. The Z-axis cells are located in the top left corner cells of each component 2D table.