

# EESy Solutions

Engineering Equation Solver Newsletter

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## Welcome

This is the 18<sup>th</sup> issue of **EESy Solutions**, a newsletter developed to provide news, tips, and tricks relating to Engineering Equation Solver. Did you miss any of the previous issues? The previous 17 issues are available from our web site: [www.fchart.com](http://www.fchart.com).

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## Instant Update Service

Each time there is a change in the EES program, either to correct a problem or to add a new feature, the version number is incremented by 0.001 and the latest version is placed on our website. There have been over 200 new versions released since the last EESy Solutions was composed in Spring 2007. Any user who has current subscription to our Instant Update Service can download the latest version. All new licenses of EES are provided with one year of Instant Update Service. The fee to continue Instant Update Service after the first year is 20% of current cost of the program per year. Contact F-Chart Software if you wish to re-subscribe to Instant Update Service.

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## What's New?

As in years past, literally hundreds of changes have made to EES during the past year. The capabilities of the program continue to grow and become more robust. What follows is a short description of some of the new capabilities.

### Mathematical Operations in Lookup Tables

Values can be entered into a column of a Lookup tables using an equation, similar to capability provided in spreadsheet programs. The equation can refer to values in other columns of the table and to defined EES variables and functions. Values in a column are represented in the equations with #n where n is the column number. For example, to convert temperatures in °C in column 1 of the Lookup table to values in K in the selected column, enter `convertTemp(C,K,#1)`. An example of this new capability appears later in this issue.

### Heat Transfer Libraries

The most impressive new capability in EES is the addition of the heat transfer libraries. These libraries were developed to accompany the upcoming book: *Heat Transfer* by G.F. Nellis and S.A. Klein, Cambridge University Press, 2009. The libraries provide an extensive selection of functions that provide convection relations, fin efficiencies, radiation view factors, shape factors, heat exchanger relations and pressure loss information. Because these functions add so much capability to EES, a decision was made to include them with all licensed copies of EES. More information on these libraries is provided in this issue.

### Thousands Separator Formatting

An option has been provided to display a separator (comma for the U.S. system and decimal point for the European system) in numerical values that are displayed in plots, tables and the Solution window.

### Multiple Levels of Undo/Redo

A popular request has been fulfilled by the addition of 8 levels of Undo/Redo in the Equations window.

### Improved Optimization

A variation of the Neider-Mead optimization algorithm has been implemented in the Professional version. This algorithm, which does not use derivatives is able to find an optimum more reliably than the Direct Search and Variable Metric methods implemented in EES for some types of problems..

### Library Manager

With the addition of the Heat Transfer library files, a large number of library files are loaded by default at startup, requiring memory and time. The Professional version provides a Library manager to control which external files are automatically loaded when EES starts. The Library manager has been revised to allow easy control over which functions are automatically loaded when EES is started.

Easy Entry of Arrays

Array values can now be entered with a shorthand array range notation, e.g.,

```
X[1..4]=[11, 22, A*B, Z^2]
```

New Property Data and Property Functions

Property data have been provided for refrigerant R423A and ideal gases Argon (Ar) and Helium (He). New property functions have been provided for the Lennard-Jones energy (ek\_LJ) and length (sigma\_LJ).

Improved Import/Export Capabilities

The \$IMPORT directive provides an option to skip a specified number of lines before reading a file with the /skiplines=xx clause. The \$EXPORT directive provides several new options. The format of each numerical value in the \$EXPORT statement can be followed with a format specification that controls how it is written to the file. Appending A causes the value to appear in the same format as seen in the Solution window. Fn and :En format for fixed decimal or exponential format with n digits where n is an integer between 0 and 9. Also, the filename appearing the \$EXPORT directive can have a .DAT and .TAB filename extension, in addition to the existing .CSV and .TXT options. .DAT files separate values with one space and .TAB files separate value with a tab character.

Format Specification for Lookup Files

LOOKUP files that are read into a LOOKUP Table can be read with a format specification using the \$OPENLOOKUP directive, the OPENLOOKUP macro command or the Open Lookup menu item in the Tables menu. The format specification is provided in an .FMT file.

Linear Regression Command Improvements

The Linear Regression command in the Tables menu now allows up to 9 independent variables (previously 6) and up to 100 adjustable parameters (previously 40). It also provides a Plot button that will produce a plot of the predicted values of the dependent variable from the regression equation versus the values provided in the table.

Tips and Tricks

Some of the new capabilities in EES are demonstrated in this section.

Formatted Reading of Data in Lookup Tables

A format specification can now be used to read data into a Lookup table. A common use for this capability is to read typical mean year weather data files into EES. Typical mean year weather data files are provided by National Renewable Energy Laboratory (NREL) for 239 locations at: <http://www.nrel.gov/rredc>. The format for data elements in .tm2 files is provided at: <http://rredc.nrel.gov/solar/pubs/tmy2/tab3-2.html>. It is difficult to read these files because the data for each hour are placed in one record with no spaces between them. In addition, non-numerical flags are interspersed within the records. However, the /Format option for the \$OPENLOOKUP command makes this process easy. A format specification file is first created. The format specification file has an .fmt filename extension. Any line that begins with // is a comment and is ignored. A skip command can be placed in the file to skip a specified number of lines of header information. A row is provided for each item that is to be read indicating the column range, the display specification, the name to appear in the column header and optionally, the units. Shown below is file tmy2.fmt file that will read selected columns from .tm2 files:

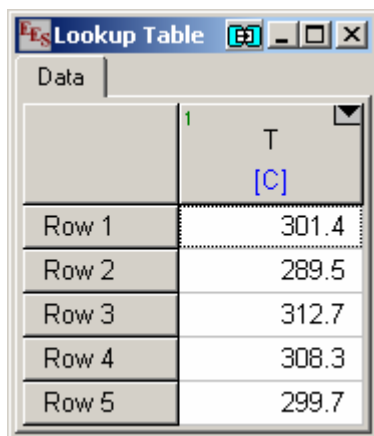
```
//this is a format specification for .tm2 files
skip 1
2-3    F0      year
4-5    F0      Month
6-7    F0      Day
8-9    F0      Hour
10-13  A       G_o      W-hr/m^2
18-21  A       G         W-hr/m^2
24-27  A       DNI      W-hr/m^2
30-33  A       G_D      W-hr/m^2
68-71  A       T_a*10   C
74-77  A       T_dp*10  C
80-82  A       RH       %
85-88  A       P_a      millibar
96-98  A       Wind     m/s
```

As an example, the following short program will read the weather data from the .tm2 for Madison, WI into EES.

```
F$='US-WI-Madison-14837.tm2'
$OPENLOOKUP F$ /Format=tm2.fmt
```

### Mathematical Operations in Lookup Tables

A common use for Lookup tables is to hold experimental data. Often, these data are measured in different units than needed in the data analysis, necessitating unit conversion. For example, suppose that you entered the following temperature measurements into a Lookup table named 'Data'.



|       | 1        | 2         |
|-------|----------|-----------|
|       | T<br>[C] | TK<br>[K] |
| Row 1 | 301.4    |           |
| Row 2 | 289.5    |           |
| Row 3 | 312.7    |           |
| Row 4 | 308.3    |           |
| Row 5 | 299.7    |           |

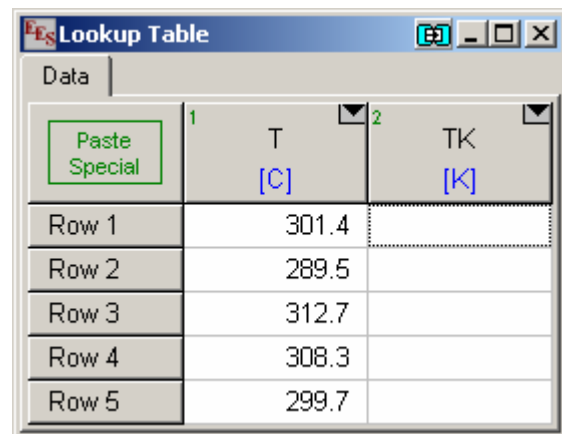
The temperatures can be directly read into an array with a duplicate loop. However, your analysis requires the temperatures be in K, and so another array is used to hold the converted temperature.

```
duplicate i=1,5
  T[i]=Lookup('Data', i, 'T')
  TK[i]=convertTemp(C,K,T[i])
end
```

There is no obvious limitation in reading data from the Lookup table and converting the units in this manner. However, there are several disadvantages to this approach. First, two arrays (T and TK) are used for temperature. If there are only 5 rows in the Lookup table, this is of no consequence, but it would be if there were, for example, 1,000 rows. Each array variable is counted against the 6,000 variable limit (12,000 for the Professional version) so a significant fraction of the variable space has been wasted by

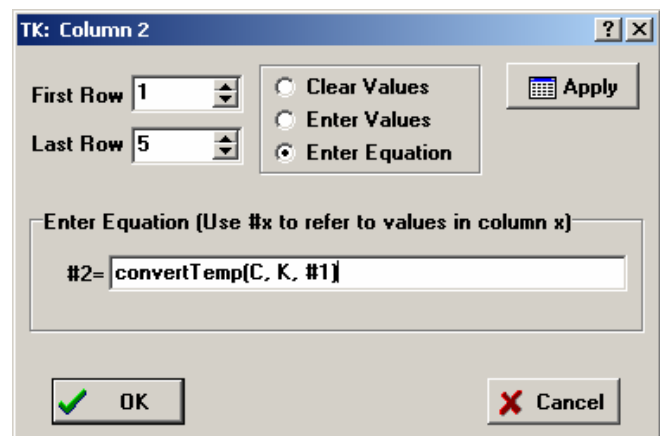
defining both arrays T and TK. Second, the conversions need to be recalculated each time the EES program is run. Third, EES will not allow any of the variables in the TK array to be included in an uncertainty analysis since it appears to EES that variables in the TK array are calculated quantities rather than assignment statements.

A better way to accomplish this unit conversion would be to create a second column in the Lookup table with name TK and units of K.



|       | 1        | 2         |
|-------|----------|-----------|
|       | T<br>[C] | TK<br>[K] |
| Row 1 | 301.4    |           |
| Row 2 | 289.5    |           |
| Row 3 | 312.7    |           |
| Row 4 | 308.3    |           |
| Row 5 | 299.7    |           |

The values of temperature in K can be automatically converted and entered into the TK column by clicking on the triangle at the upper right of the TK header cell. Click on Enter Equation and enter the equation shown below



TK: Column 2

First Row: 1  
Last Row: 5

Clear Values  
 Enter Values  
 Enter Equation

Apply

Enter Equation (Use #x to refer to values in column x)

#2= convertTemp(C, K, #1)

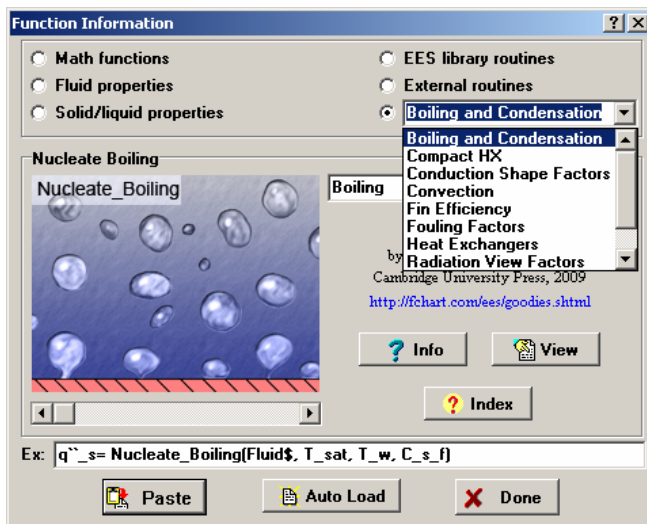
OK Cancel

Clicking Apply or OK will fill the TK column with the converted temperatures. Note that any relationship can be entered as the equation using EES functions and variables that have been previously defined. The #1 notation in the above

example is replaced with the value in the same row in column 1 when Apply/OK is entered

### The Heat Transfer Library

The heat transfer library represents the largest contribution to EES capabilities since the inclusion of physical property data functions. The library is accessed through the Function Information dialog by clicking the radio button at the lower right of the top panel. A selection of heat transfer topics will appear, as shown.



The boiling and condensation function provide functions to estimate the heat transfer coefficient for many two-phase flow situations including nucleate boiling, flow boiling, flow condensation, and quiescent condensation of saturated vapor on a variety of surfaces.

The Compact Heat Exchanger (Compact HX) library provides empirical airside heat transfer and pressure drop information for finned tube surfaces. The data on which these functions are based were compiled and published by Kays, & London, Compact heat exchangers, 3rd ed., McGraw Hill, New York, 1984. Three sets of functions are provided: a) geometric parameters of the heat exchanger; b) airside heat transfer coefficient in both dimensional and non-dimensional forms and c) air-side pressure loss.

These functions greatly simplify the analysis of cross-flow heat exchangers.

Conduction shape factors provide a simple means of calculating the rate of heat transfer for 2-D or 3-D geometries.

Anyone who has taken a heat transfer class will appreciate the convection libraries. Functions are provided for internal and external flow, as well as for free convection. All of the functions are provided in both non-dimensional and dimensional forms. The non-dimensional form relates the Nusselt number to the Reynolds and Prandtl numbers, whereas the dimensional forms use the provided pipe dimensions, flow rate, temperature and pressure to return the heat transfer coefficient and pressure loss. Consider the flow of a fluid through a tube as an example. To determine the heat transfer coefficient, it is necessary to first calculate the Reynolds number to determine whether the flow is laminar, transitional or turbulent. Appropriate heat transfer and friction factor correlations next need to be selected based on the Reynolds number. If the tube is short relative to its diameter, the boundary layer is not fully developed and corrections must be applied to the heat transfer coefficient and friction factor. If the flow is turbulent, the boundary layer is thin enough to be affected by the surface condition, requiring an addition correction or alternative correlation. The entire process can be accomplished in a single function call within EES as shown below.

```
call PipeFlow ('air',T,P,m_dot,D,L,RelRough:&
h_T, h_H ,DELTA_P, Nusselt_T, f, Re)
```

A book would be needed to explain all of the capabilities that are provided by the heat exchanger library. Fortunately, the book will soon be available – see Page 1. Note that many examples from the book can be downloaded from the fChart website.