EESy Solutions

Engineering Equation Solver Newsletter ***No. 12, Spring 2002***

Welcome

EESy Solutions is a newsletter developed to provide news, tips, and tricks relating to Engineering Equation Solver. **EESy Solutions** is provided at no cost to all registered users of EES. Did you miss any of the previous issues? These newsletters and other useful information can be downloaded from our web site: www.fchart.com.

Instant Update Service

Instant Update Service was initiated in Spring, 2001. This service provides subscribers with an account name and password to our server from which they can download the latest Commercial or Professional version of EES whenever they wish to do so. In the last twelve months, 278 new versions of EES were released to fix bugs and add new capabilities. The cost for this service is 25% of original cost of the program per year. The update is also available on a CD for the same price plus mailing costs. Contact us if you wish to order either type of update. Starting April 15, 2002, Instant Update service will be included for one year with all new EES license sales. The price of Commercial and Professional versions will be $500 and $1,000, respectively.

McGraw-Hill Academic Versions

Limited Academic versions of EES are provided on a CD with several McGraw-Hill textbooks. The capabilities of the Limited Academic version are restricted and it is not able to print or save files. Fully functional Academic versions of EES are provided by McGraw-Hill to educational institutions in the U.S that adopt selected McGraw-Hill textbooks at no cost for the adoption period. Educational site licenses can also be obtained from McGraw-Hill independent of any textbook adoption.

www.mhhe.com/engcs/mech/ees/index.mhtml

F-Chart Software distributes Commercial and Professional versions and Academic versions to institutions located outside of the U.S.

What's New?

Hundreds of changes have made to EES as a result of suggestions from students and commercial users. What follows is a short description of some of the more important new capabilities.

Property Data

A major difference between EES and other equation solvers is the extensive library of thermodynamic and transport properties that are provided in EES. During the last year, the property data base has been extended in the following ways.

A Solid/Liquid properties package provides the thermal conductivity, density, specific heat, viscosity, volumetric thermal expansion coefficient, elastic modulus, linear coefficient of thermal expansion, and Poisson's ratio for many solid and liquid substances as a function of temperature. Examples and online help for these functions can be accessed with the **Function Info** menu item in the **Options** menu by clicking on the Solid/Liquid properties radio button. As an example, the thermal conductivity of copper at a temperature of 500 (K, C, R or F depending upon the EES units setting) is obtained with the EES k_ function:

k=k_('copper', 500)

Property data have been added for Xenon, C2H5OH, C6H14, C8H18, R123, R125, R508B, Ice, and Air_ha. Air_ha provides real property data for air at temperatures between 60 K and 2000 K and at pressures up to 2000 MPa using a high accuracy equation of state.

A new $REFERENCE directive allows the reference state for specific enthalpy and entropy of fluids represented by the high accuracy properties to be specified to one of four commonly used reference settings.

AcentricFactor, Fugacity and SoundSpeed property functions have been implemented.

Surface tension data have been implemented for the blends, R404A, R407C, R410A, and R507C.

Property data for R22, R134a, ammonia, and propane are now based on a high accuracy equation of state, replacing the less accurate Martin-Hou implementation used in earlier versions.

Transport data for air, H2, O2, N2, CO2, CO, CH4, and Helium have been extended.

Holding the Ctrl and Shift keys down on any Property plot displays all thermodynamic properties corresponding to the state at the cursor position.

Psychrometric charts produced by the Property Plot command now offer the option of constant volume lines.

Computational Improvements

A major purpose of EES is to simplify the development of a program that solves your problem. A number of new capabilities have been added for this purpose.

Perhaps the most powerful addition to the computational power of EES is the addition of Subprograms. A Subprogram is a stand-alone EES routine that can be accessed with the CALL statement, similar to a Module. The difference is that the equations in a Module are merged into the Main program whereas those in a Subprogram remain independent of the main program. It is possible for a Function or Procedure to call a Subprogram. Since Functions and Procedures can use logic statements, the ability of Functions/Procedures to call a Subprogram increases the range of problem types that EES can solve.

The Interpolate2D function extends the ability of the Interpolate commands by allowing interpolation as a function of two independent variables.

The units for Pressure can be Pa or MPa, in addition to the kPa, and bar choices offered previously. Energy quantities can be specified in J or kJ.

Unit Checking

Improper conversion of units is perhaps the most common cause for incorrect results from a numerical analysis. This problem occurs not only for engineering students, but for professionals as well. The publicized failure of the NASA mars lander is one example of an expensive mistake caused by a lack of attention to units. In the last year, the capabilities in EES to check units have been extended in the following ways:

Automatic unit checking can be specified with an option in the Preferences dialog or with the $CHECKUNITS On directive. With automatic unit checking, units are checked when the calculations are done. The Solution window will indicate the number of equations that fail the unit checking tests, if any. The Residuals window will display a column indicating the success of the unit checking for each equation. Both windows provide access to the Check Units command which facilitates the process of making corrections.

Unit checking has been extended to equations that reside in Functions and Procedures. Previously EES would not check such equations. Units for variables in Functions and Procedures can be entered either as a comment in the Equations window or by right-clicking on the variable in the Solution window. The units returned from an external function can also be set in this manner.

The unit checking algorithms will accept units raised to fractional powers, e.g., [K^0.5].

Uncertainty Analyses

Uncertainty analysis is a necessary part of any experimental investigation. However, the propagation of the uncertainty associated with measured quantities in the determination of a calculated result can be computationally involved. The capabilities to do uncertainty propagation in EES have been extended in the following ways:

The % of uncertainty in a calculated variable resulting from the uncertainty in each measured variable is displayed in the Solution window after the Uncertainty Propagation or Uncertainty Propagation Table calculations are completed.

The uncertainty associated with a variable calculated by EES is displayed in the Solution window or Parametric table, but it is otherwise not accessible. The **UncertaintyOf** function returns the uncertainty associated with the variable provided as the argument to the function so that it can be used in further calculations.

The uncertainty values used in the Uncertainty Propagation and Uncertainty Propagation Table commands can now be supplied as numerical constants or as EES variables.

When using the Uncertainty Propagation Table command, the sum row in the Parametric table will display the uncertainty of the summed values, calculated as the square root of the sum of the squared uncertainty values from each row.

Plot Window Enhancements

A plot can be duplicated by right-clicking on the tab at the top of the window. The duplicate plot capability provides an easy way to create a plot template.

A column of strings from the Parametric, Lookup or Arrays table can be selected as the X-axis variable for X-Y and bar plots. The X-axis will then display the strings rather than numerical values to produce a set of labeled results.

Text and objects drawn in a Plot window can be copied to another Plot window in the same program or to the Plot window of another instance of EES. Objects (e.g, lines, boxes, pictures) can be copied between the Plot and Diagram windows.

The Modify Plot dialog now permits the size of major and minor ticks in Plot windows to be changed.

New Directives

Directives are instructions to EES that appear in the Equations window. The following directives were added in the last year:

$CheckUnits On/Off
  controls automatic unit checking

$LocalVariables On/Off
  controls the display of local variables (in Functions, Procedures, Modules, and Subprograms) in the Solution and Residuals windows

$Private
  controls whether external routines can be seen from in the Function Information dialog

$Reference Fluid (ASH, IIR, NBP, or DEF)
  allows the reference state used for values of specific enthalpy and entropy for fluid to be set to one of four alternatives. ASH and IIR are reference states used by ASHRAE and the International Institute of Refrigeration, respect-tively. NBP sets a reference state based on the normal boiling point. DEF is the default.

$SumRow On/Off
  controls whether a Sum row is visible in the parametric table

$TabWidth tabspacing
  controls the spacing between tab stop in the Equations window

Professional Version

The Library Manager controls which files are automatically loaded from the USERLIB folder when EES is started.

A 3-dimensional plotting package allows the user to control colors and scaling of three dimensional plots. The plot image can be rotated in any direction by dragging the mouse on the plot.

Formatted text can be placed in the Diagram and Child Diagram windows. Formatted text can include paragraphs or tables copied from other applications. EES variable information can be inserted into the formatted text item to create a report with information reflective of the most recent calculation.

Tips and Tricks

Most of the comments we have received concerning **EESy Solutions** have asked to continue providing tips on the use of EES that are not well-known or documented in the manual. Here are a few of our favorites.

Reading a Corrupted File

We hate to admit it, but sometimes EES will corrupt a file during the file save process. If you have experienced any access errors or other unusual operation, you should save your file with a different name, so that you do not destroy the previously saved file. In the event that you do encounter a corrupted file, there are two ways that you may be able to recover it. First, try holding the Ctrl and Shift keys down while opening the file. With these keys pressed, EES will read the file in a protected manner and it will not read the plots where the corruption seems to occur. Your equations, variable information, and tables will be recovered. If this doesn't work, open the file in Notepad. You should see your equations there and be able to copy them to a new EES file.

Calculating the Limit of an Integral

The algorithm used in EES to evaluate integrals does not allow evaluation of the integral unless the integration limits are specified. However, there is a way around this limitation. This capability is best illustrated by an example. Suppose you wish to determine the value of z that satisfies the equation

$$0.5 = \int_0^z x^2 \, dx$$

You could enter this equation into the Equations window as

```
0.5 = integral(x^2,x,0,z)
```

However, EES cannot solve this equation. Instead, enter the following equation:

```
f =abs(integral(x^2,x,0,z) - 0.5)
```

Now use the Min/Max command to minimize f with respect to z.

Improving Convergence

Some sets of equations are just difficult to solve. Good guess values may help, but finding an appropriate set of guess values may be a frustrating task. The most important tool in coaxing a set of equations to a solution is the Residuals window. The residuals window not only shows the equations in the order in which the calculations occurred, but it also shows (with bold font) the variable(s) that are being solved for in each equation. The block number indicates how the calculations were set up by EES. All equations in block 0 are solved one at a time for a single variable in the order indicated in the Solution window. Then, the equations in block 1 are solved simultaneously, followed by block 2 and so on. Examination of the residuals will indicate which block EES was in when the calculations were halted. Examine the equations in this block carefully as often the solution problem can be traced to an incorrect equation. Equations having a block number in bold font indicate that the equation was not solved successfully.

In some cases, convergence can be enhanced by rewriting the equations in a different manner. This is particularly true when algebraic expressions appear as arguments in transcendental functions. In such cases, it is helpful to use a new EES variable to represent the algebraic expression and then replace the algebraic expression with this variable. This technique is illustrated in the following simple example.

```
x = 0.004;  alpha = 1e-7;  y = 0.8
y = erf(x/(2*sqrt(alpha*time)))
```

The intent of the above equations is to determine the value of variable time. EES will not solve this equation set with the default guess values. However, a solution will be obtained if the equations are rearranged as follows:

```
x = 0.004;  alpha = 1e-7;  y = 0.8;
y = erf(Value)
Value = x/(2*sqrt(alpha*time))
```