F-Chart Software

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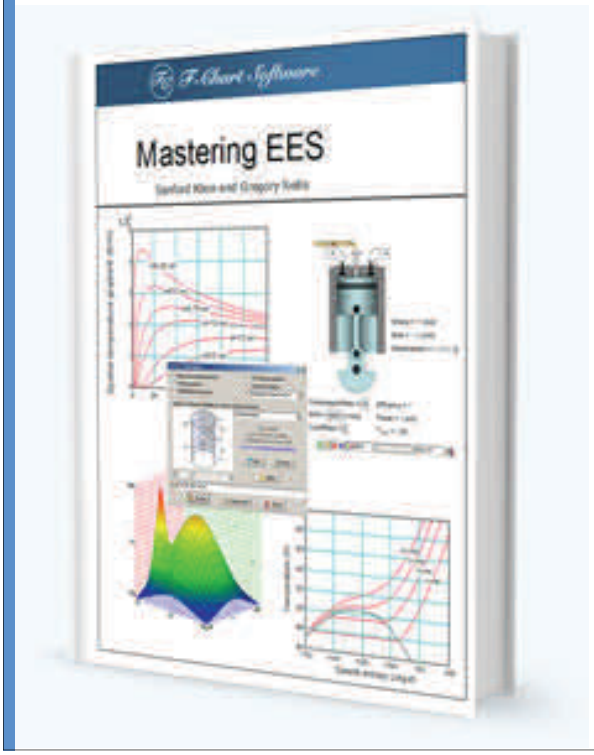
EESy Solutions

Engineering Equation Solver Newsletter

Inside this issue:

Welcome

This is the 23rd issue of EESy Solutions, a newsletter that is developed to provide news, tips, and other updates to users of the Engineering Equation Solver software. EES has been a commercially available for more than two decades and EESy Solutions newsletters were initiated in 1996. If you have missed any of the previous issues of EESy Solutions, they can be downloaded from www.fchart.com.



Mastering EES

The book *Mastering EES* has been published by F-Chart. The book provides a comprehensive presentation of all of the features of the Commercial and Professional versions of EES complete with many examples.

Mastering EES provides the introductory material appropriate for new users. Later chapters present in-depth coverage of all of the advanced features in EES.

Mastering EES is available as a downloadable e-book for $25 from http://fchart.com/ees/mastering-ees.php. The first chapter of this book, which provides the best information for new users, is available at no cost from this site.

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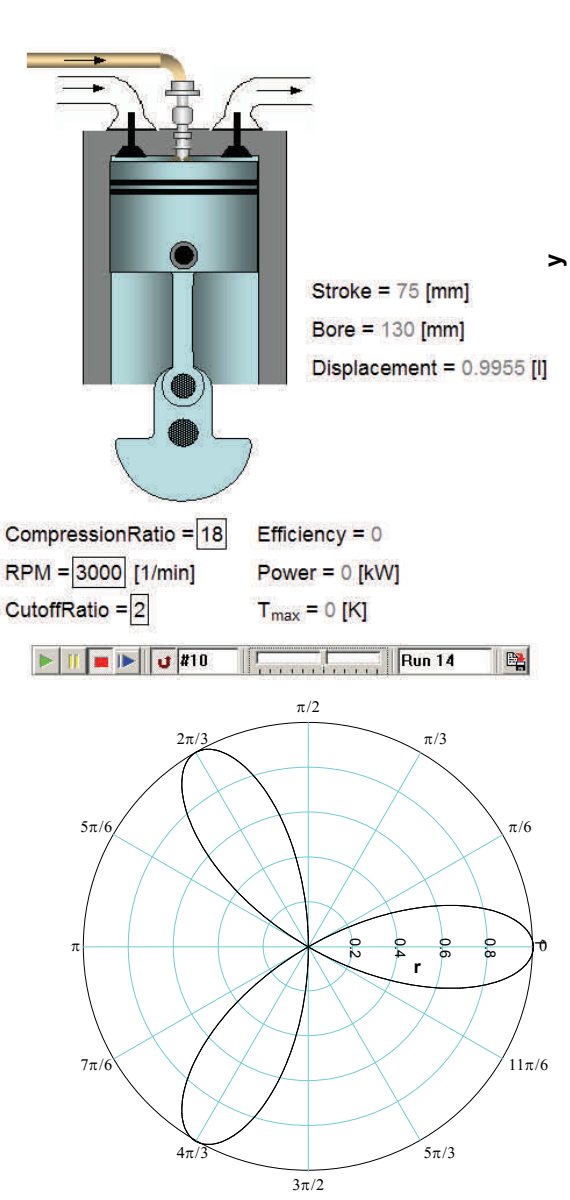
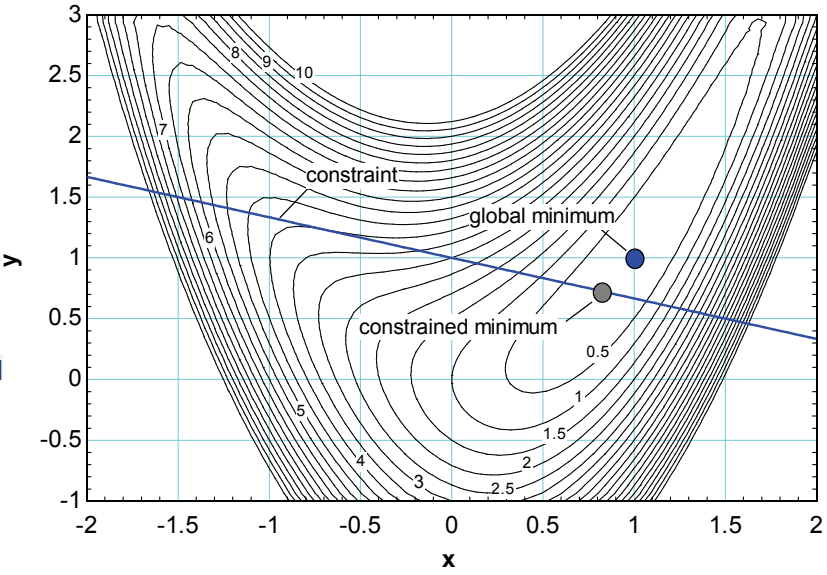
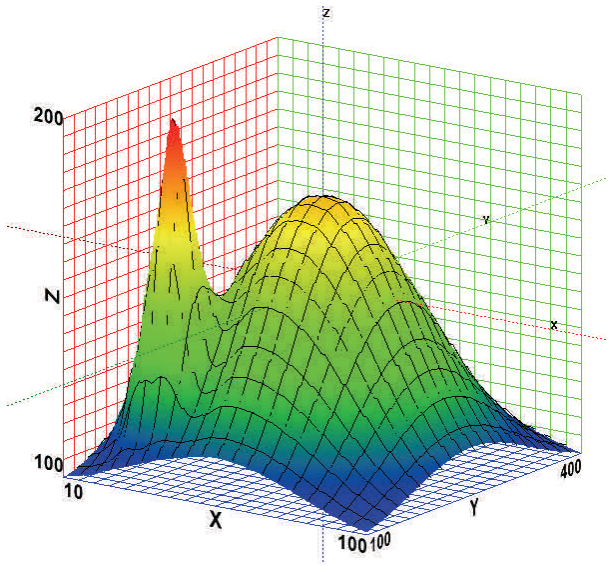
Mastering EES

Heat Transfer and *Thermodynamics* are new engineering textbooks (http://www.cambridge.org/us/Nellis_Klein/) written by S.A. Klein and G.F. Nellis. The presentation of the theory in both textbooks is tightly integrated with the use of EES, which is used to solve problems. However, these books are intended primarily to teach heat transfer and thermodynamics rather than the use of EES. *Mastering EES* is very different from these textbooks. This book is meant specifically to teach users of EES how to become more effective in using the program. The features of the program are illustrated sequentially, from properties to macros and everything in between. The presentation is thorough and uses a conversational tone with many examples.







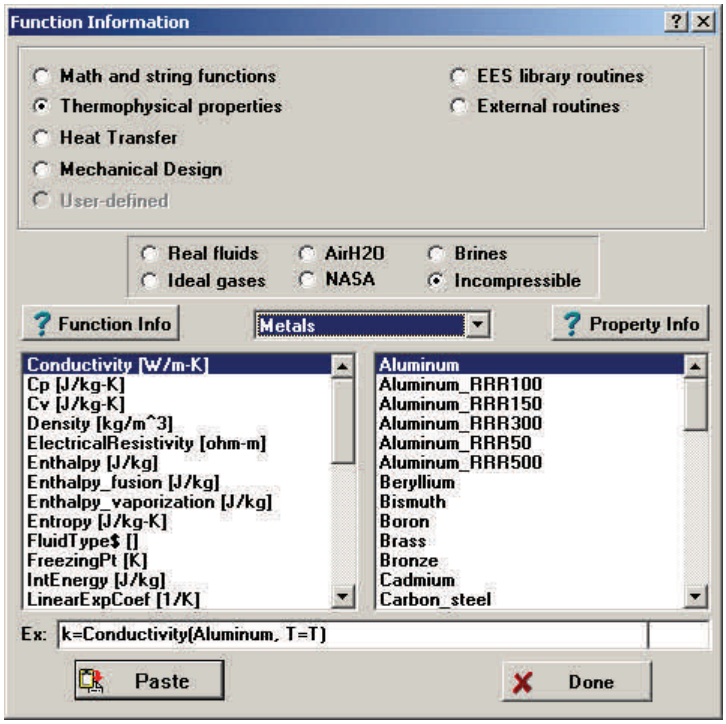
Images from *Mastering EES* by Klein and Nellis

Mastering EES Table of Contents

Thermophysical Properties of Incompressible Substances

A rich set of thermophysical properties is provided in EES for incompressible substances. These property data are in addition to the extensive library of compressible fluids for which EES is known. The incompressible fluid database has recently been significantly upgraded, both in terms of the breadth of property data as well as the interface.

The incompressible substance library has been altered so that it is accessed using the same function name and form as the other properties in EES. To access these properties, select Function Information from the Options menu and then select the Thermophysical properties radio button. The properties in EES are now broken down into six categories:



Real fluids: These are compressible fluid models that describe the substance in liquid, two-phase, and superheated states based on a high accuracy equation of state.

Ideal gases: Ideal gas fluids consider the temperature dependence of c_P and c_v and the reference states are consistent with stable elements at standard conditions in order to facilitate the use of these properties in problems involving chemical reactions.

NASA: These fluids are contained in the NASA ideal gas data base developed by McBride et al. (2002). These fluids also provide property data appropriate for calculations involving chemical reactions. Transport properties are not included for these fluids.

AirH2O: This fluid is a mixture of air and water vapor.

Brines: These secondary heat transfer fluids are mixtures of water and another substance with a variable concentration. The property correlations are obtained from Melinder (2010).

Incompressible: These are incompressible solids and liquids. With the exception of specific enthalpy, the thermodynamic and transport properties of an incompressible substance are only functions of temperature. These properties are obtained by interpolation from data tables provided with EES.

Previously, the incompressible substance properties were accessed from the separate Solid/Liquid database using different function names than those used in the other categories. For example, thermal conductivity was obtained using the function k_ as opposed to Conductivity. Many functions available for the other categories were not available for incompressible substances; for example, Enthalpy, intEnergy, and Entropy.

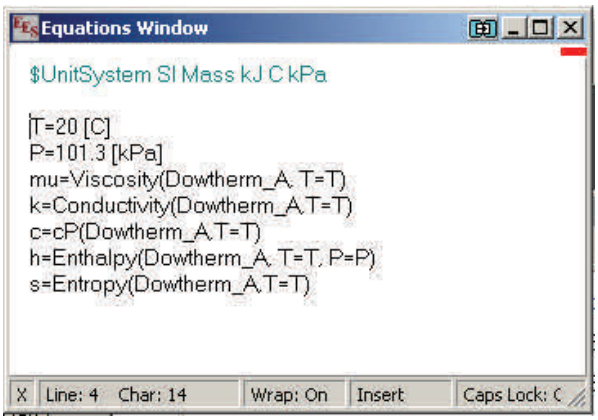
While the old function names continue to work, it is now possible to use any of the functions that are available for the other categories with an incompressible substance.

McBride, B.J., Zehe, M.J., and Gordon, S "NASA Glenn Coefficients for Calculating Thermodynamic Properties of Individual Species", NASA/TP-2002-211556, Sept. (2002), http://gltrs.grc.nasa.gov/reports/2002/TP-2002-211556.pdf

Melinder, Å *Properties of Secondary Working Fluids for Indirect Systems*, IIF/IIR, 2010, http://www.iifiir.org/en/details.php?id=1177

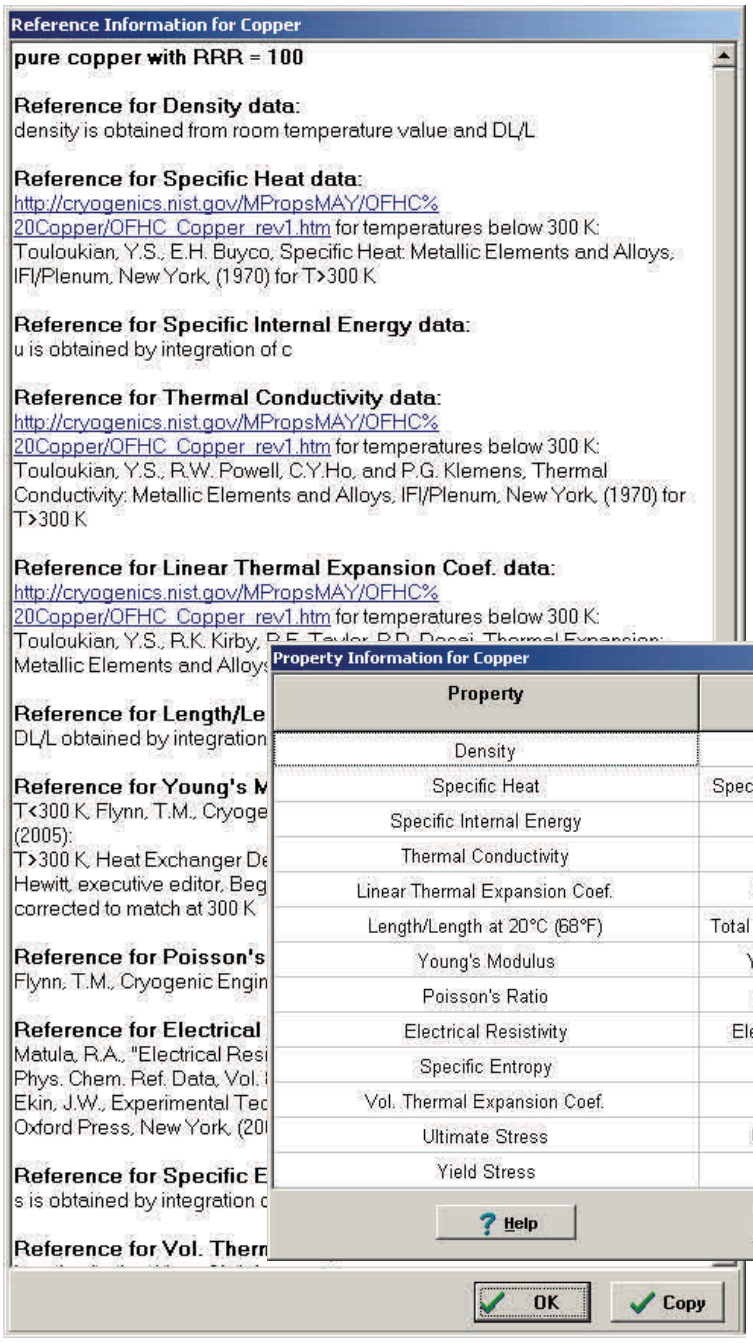
Thermophysical Properties of Incompressible Substances

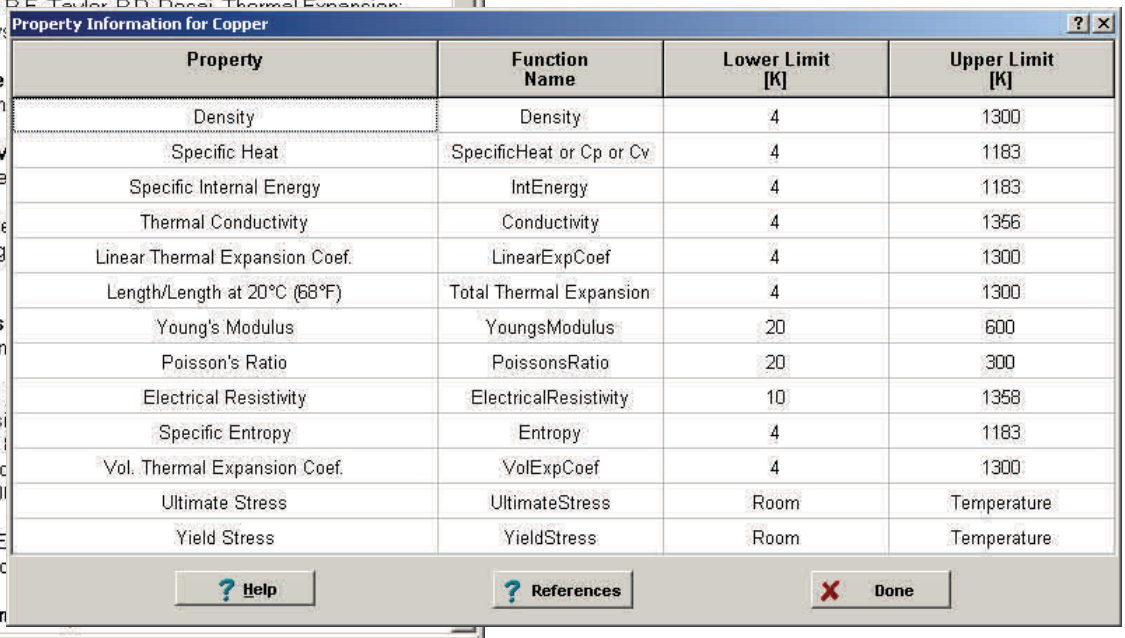
The incompressible substances are further subdivided into categories that may be accessed from the drop-down menu: All Data, Building Materials, Heat Transfer fluids, Insulation, Liquid Metals, Metals, Miscellaneous, Molten Salts, and Organic Liquids. For example, select Heat Transfer fluids in order to access a list of the built-in heat transfer fluids that are available. The EES code to the right provides the viscosity, conductivity, specific heat capacity, specific entropy and specific enthalpy of the heat transfer fluid DOWTHERM A at 20ºC.



In addition to improvements to the interface, the underlying data used for the property correlations has been greatly extended and improved. In order to obtain the temperature range associated with the data for a given substance and property select the substance name and then click the Property Info button. The popup window that results shows the properties that are available as well as the temperature range for each property. Select the References button in order to see the source of each set of data.

Several new functions have been added for incompressible substances, including electrical resistivity, enthalpy of vaporization, normal boiling point, critical properties and molar mass.





Thermophysical Properties of Incompressible Substances

The table below lists the current set of metals together with the range of the correlations (in K). Note that RT indicates that only a room temperature value is available and NA indicates that this property is not available.

Metal	Specific heat capacity, c [1]	Conductivity, k	Thermal expansion coefficient, α[2]	Young's modulus, E	Poisson's ratio, ν	Electrical resistivity, ρ_e
Aluminum[3]	1.1 - 923	4 - 933.2	5 - 900	20 - 575	20 - 300	80 - 933.5
Beryllium	10 – 1200	10 – 1400	100 – 1200	RT	RT	1 – 1500 K
Bismuth	10 – 400	10 – 500	100 – 400	RT	RT	200 - 400
Boron	100 – 1000	10 – 1000	293 – 1000	RT	RT	200 – 1000
Brass	25 – 800	2 – 523	20 – 775	293 – 700	RT	240 – 400
Bronze	20 – 300	173 – 600	17 – 675	83 – 675	RT	250 – 350
Cadmium	10 - 400	1 – 400	100 – 400	RT	RT	250 – 350
Carbon steel	273 – 1273	15 – 1073	50 – 1000	200 – 773	RT	250 – 350
Carbon steel AISI 1010	300 – 1000	173 – 1173	173 – 1173	173 – 873	RT	250 – 350
Chromium	10 – 2000	1 – 2000	100 – 2000	RT	RT	100 – 1200
Cobalt	10 – 1200	10 – 1500	100 – 1200	RT	RT	250 – 350
Copper[4]	4 – 1183	4 – 1356	4 – 1300	20 – 600	20 – 300	10 – 1358
Germanium	10 – 1200	10 – 1200	100 – 1200	RT	RT	RT
Gold	15.8 – 1164	1 – 1336	2 – 1300	RT	RT	1 – 1336
Inconel X750	200 – 1000	200 – 1000	200 – 1000	300 – 1100	RT	300 – 1100
Iridium	10 – 1500	10 – 1500	100 – 1500	290 – 1573	290 – 1573	100 – 700
Iron	1.5 – 1523	2 – 1500	5 – 1185	20 – 300	20 – 300	20 – 273.2
Lead	10 – 600	1 – 600	100 – 600	RT	RT	20 – 600
Magnesium	10 – 800	1 – 800	100 – 800	20 – 300	20 – 300	1 – 600
Molybdenum	10 – 2500	4 – 2500	50 – 2500	300 – 2600	RT	250 – 2600
Nichrome	300 – 800	300 – 800	RT	RT	RT	290 – 1300
Nickel	10 – 1500	1 – 1500	100 – 1500	300 – 800	RT	200 – 1000
Niobium	25 – 2000	1 – 2200	100 - 2000	RT	RT	290 – 2500
Palladium	8 – 1500	10 – 1500	100 – 1200	RT	RT	1 – 1827
Platinum	1- 2000	1 – 2000	100 – 1500	300 – 1200	300 – 1200	20 – 1200
Rhenium	20 – 2000	10 – 2000	100 – 2000	RT	RT	80 – 600
Rhodium	10 – 1600	10 – 1600	100 – 1600	RT	RT	250 – 350
Silicon	100 – 1600	0 – 1600	100 – 1600	NA	NA	NA
Silver	1 – 1200	1 – 1200	100 – 1200	10 – 300	RT	1 – 1235
Stainless steel AISI 302	290 – 1000	290 – 1000	290 – 1000	RT	RT	RT
Stainless steel AISI 304	4 – 1500	4 – 1500	100 – 1500	200 – 1200	RT	1 – 1600
Stainless steel AISI 316	4 – 1000	1 – 1600	1 – 1200	8 – 1200	RT	1 – 1600
Stainless steel AISI 347	290 – 1000	1 – 1600	173 – 1173	173 – 1173	RT	1 – 1600
Tantalum	10 – 2500	1 – 3000	200 – 2500	RT	RT	290 – 2000
Thorium	100 – 1200	10 – 1500	100 – 1200	RT	RT	290 – 1400
Tin	100 – 400	50 – 500	100 – 400	RT	RT	200 – 400
Titanium	25 – 1500	1 – 1800	100 – 1500	20 – 300	20 – 300	70 – 1500
Tungsten	10 – 2500	1 – 3000	100 – 2500	RT	RT	100 – 1000
Uranium	10 – 1200	10 – 1400	100 – 1200	RT	RT	RT
Vanadium	10 – 2000	10 – 1500	100 – 2000	RT	RT	1 – 2100
Zinc	10 – 600	1 – 600	100 – 600	100 – 600	100 – 600	1 – 600
Zirconium	100 – 2000	1 – 2000	100 – 1500	200 – 800	RT	1 - 1000

1. Specific internal energy (u) and specific entropy (s) are obtained by integration of c. Specific enthalpy (h) is $u + P/\rho$. Therefore, u, s, and h have the same temperature range as c.
2. Integrated length change ($\Delta L/L_{293}$) is obtained by integration of α. Volumetric expansion coefficient (β) is obtained from α. Density (ρ) is obtained from a room temperature value modified by $\Delta L/L_{293}$. Therefore, $\Delta L/L_{293}$, β, and ρ have the same temperature range as α.
3. Aluminum refers to pure aluminum with RRR = 100. The substances Aluminum_RRR50, Aluminum_RRR100, Aluminum_RRR150, Aluminum_RRR300, and Aluminum_RRR500 provide properties for aluminum with different resistivity ratios.
4. Copper refers to pure copper with RRR = 100. The substances Copper_RRR50, Copper_RRR100, Copper_RRR150, Copper_RRR300, and Copper_RRR500 provide properties for copper with different resistivity ratios.

EES Training Opportunities

EES is used by many companies, organizations, and academic institutions. Most users are aware of the basic features—solving equations, Parametric Tables, plotting, and the powerful property routines. However, fewer users are aware of the more powerful features of EES such as optimization, integration, uncertainty propagation, complex algebra and subprograms. More advanced features available in the Professional version, such as the Diagram Window, animation, executables, directives, and macros can enhance the capabilities of the program and open the door to a wide range of applications.

Our staff are available to provide a 1 day EES short course tailored to new or experienced EES users. The cost is $1500 plus travel expenses. Contact Greg Nellis by email to arrange a training session (info@fchart.com).

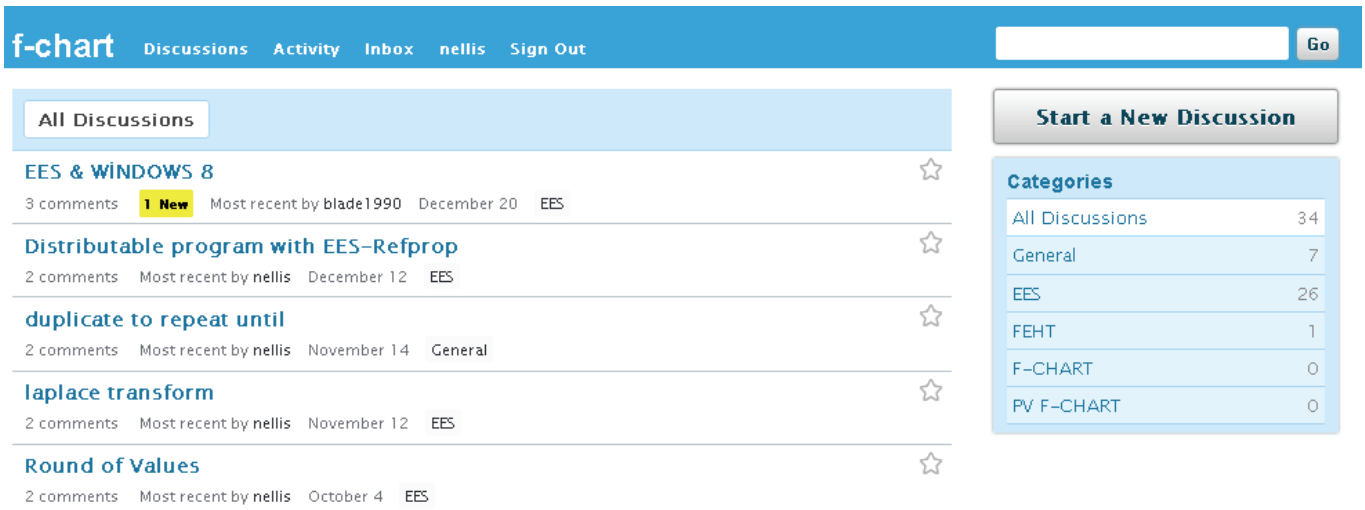
EES Training Seminar

- Introduction to EES
- Thermodynamic and Transport Properties
- Functions and Procedures
- Curve Fitting and Interpolation
- Convergence and Debugging
- Optimization
- Integration
- Uncertainty Propagation
- Subprograms and Modules
- Libraries
- Heat Transfer Library
- Complex Algebra
- Directives
- The Diagram Window
- Animations
- Distributables
- Macros
- Communicating with other programs

EES User Forum

Got a quick question? Or a solution? Or a comment?

Consider joining the EES User Forum at fchart.com (http://fchart.cl0.vanillaforums.com/) where you can post your own experiences with EES. The posts are periodically read by staff at F-Chart and provide a mechanism for users to ask questions of other users and exchange ideas and solutions.



Some Additional Changes to EES

- The function RANDG returns a randomly selected value from a Gaussian distribution.
- The functions IntEnergy, Enthalpy and Entropy can be used for brines.
- The capability of grouping items in the Diagram Window has been significantly improved.
- The T-s property plots now provide a choice of lines of constant specific volume or constant specific enthalpy.
- The OnError Goto XX macro command allows the user to control a macro in the event of an execution error.
- The internal and external flow convection libraries can be used with brines.
- The Direct optimization method has been added for the Professional version.
- Properties for dimethyl carbonate, m-xylene, p-xylene, ethyl benzene, o-xylene have been added.
- Variable information can be saved and retrieved for the main program and all functions, procedures, etc. using a .var file.
- Integral tables can be created using the $IntegralTable directive within Subprograms as well as the Main program.

F-Chart Software

Box 44042
Madison, WI

Phone/FAX: 608-274-4262
Internet: http://fchart.com
E-mail: info@fchart.com

www.fchart.com

Instant Update Service

EES uses a different model for updating than most other programs. Each time that 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 of EES is placed on our website. Although the program has become very robust and stable, there have been ***170 new versions*** since the last EESy Solutions was distributed in the Spring of 2012, which have provided many new features. A list of the new features can be found at fchart.com/ees/new-features.php.

Any user who has a 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 the current cost of the program per year. Additional information about this service is available at http://fchart.com/ees/instant-update.php. Contact F-Chart Software if you wish to re-subscribe to the Instant Update Service.