Chapter 2

Engineering Equation Solver - EES

2.1 Background

The material in this section is comprised of excerpts from the EES Manual [9]

> "EES (pronounced 'ease') is an acronym for Engineering Equation Solver. The basic function provided by EES is the solution of a set of algebraic equations. EES can also solve differential equations, equations with complex variables, do optimization, provide linear and non-linear regression, generate publication-quality plots, simplify uncertainty analyses and provide animations. ...
>
> There are two major differences between EES and existing numerical equation-solving programs. First, EES automatically identifies and groups equations that must be solved simultaneously. This feature simplifies the process for the user and ensures that the solver will always operate at optimum efficiency. Second, EES provides many built-in mathematical and thermophysical property functions useful for engineering calculations. For example, the steam tables are implemented such that any thermodynamic property can be obtained from a built-in function call in terms of any two other properties. Similar capability is provided for most organic refrigerants (including some of the new blends), ammonia, methane, carbon dioxide and many other fluids. Air tables are built-in, as are psychrometric functions and JANAF table data for many common gases. Transport properties are also provided for most of these substances. ...
>
> The motivation for EES rose out of experience in teaching mechanical engineering thermodynamics and heat transfer. To learn the material in these courses, it is necessary for the student to work problems. However, much of the time and effort required to solve problems results from looking up property information and solving the appropriate equations. Once the student is familiar with the use of property tables, further use of the tables does not contribute to the student's grasp of the subject; nor does algebra. The time and effort required to do problems in the conventional manner may actually detract from learning of the subject matter by forcing the student to be concerned with the order in which the equations should be solved (which really does not matter) and by making parametric studies too laborious. Interesting practical problems that may have

implicit solutions, such as those involving both thermodynamic and heat transfer considerations, are often not assigned because of their mathematical complexity. EES allows the user to concentrate more on design by freeing him or her from mundane chores.

EES is particularly useful for design problems in which the effects of one or more parameters need to be determined. The program provides this capability with its Parametric Table, which is similar to a spreadsheet. The user identifies the variables that are independent by entering their values in the table cells. EES will calculate the values of the dependent variables in the table. The relationship of the variables in the table can then be displayed in publication-quality plots. EES also provides capability to propagate the uncertainty of experimental data to provide uncertainty estimates of calculated variables. With EES, it is no more difficult to do design problems than it is to solve a problem for a fixed set of independent variables.

EES offers the advantages of a simple set of intuitive commands that a novice can quickly learn to use for solving any algebraic problems. However, the capabilities of this program are extensive and useful to an expert as well. The large data bank of thermodynamic and transport properties built into EES is helpful in solving problems in thermodynamics, fluid mechanics, and heat transfer. EES can be used for many engineering applications; it is ideally suited for instruction in mechanical engineering courses and for the practicing engineer faced with the need for solving practical problems."[9]

2.2 Procedures

This lab consists of working through two EES practice problems. The first is a thermodynamics problem illustrating the property lookup, plotting, and table generation capabilities of EES. The second problem demonstrates the interpolation derivative and curve fitting functions of EES. You should generate a report following each practice problem. These reports are to be included with the lab report.

2.2.1 Property Lookup, Table Generation, and Plotting

Work through Example 1-1 of the EES manual; duplicating the steps and the analysis. The EES manual is a pdf-format file and can be located at `c:\ees32\ees_manual.pdf`. Example 1-1 begins on page 9 of the text (page 15 of the pdf file). **Generate and print a report for inclusion in the lab report.**

2.2.2 Interpolate, Derivative, and Curve Fitting Functions

The following exercise is similar to that found in the `copper.ees` example. This example is located in `c:\ees32\userlib\examples\` directory and can be loaded into EES by selecting the `Interpolating a table` example from the `Examples` — `Interpolate function` menus.

1. Create a "Lookup" table in EES with the density of water and ethanol as a function of temperature from 0 to 100 °C in 10 °C increments.
2. Use the "Interpolate" function to estimate the density of ethanol and water at 27 °C and 61 °C.
3. Verify the EES result with at least one hand calculation.
4. Use the "Derivative" function to determine the rate of change in density as a function of temperature at 30 °C.
5. Verify the EES result with at least one hand calculation.
6. Plot the densities of the two fluids as a function of temperature and generate a curve fit of the data.
7. Generate and print a report for inclusion in the lab report.

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