



## 1.1. Introduction

EES stands for Engineering Equation Solver. It is a wonderful and a powerful software. EES solves large sets of Algebraic and differential equations. EES provides publication-quality plots, linear and nonlinear regression. In this sessions, we will cover and touch various topics which include:

1. Getting the thermodynamics properties for various substances, such as enthalpy, entropy, etc.
2. Creating the parametric and arrays tables.
3. Plotting P-v, T-s, P-h diagrams.
4. Solving the whole power plant cycles and refrigeration cycles.

## 1.2. EES Features

EES commands are distributed among nine pull-down icons.



The **File** menu provides commands for loading, merging, and saving work files and libraries, and printing.

The **Edit** menu provides commands for the editing commands for cut, copy, and past information.

The **Search** menu provides find, replace commands for use in the equation window.

The **Option** menu provides commands for setting the guess values bounds of variables, units system, and default information.

The **Calculate** menu contains the check, format, and solve the equation set.

The **Tables** contain commands to set up and alter the content of the parametric and look up tables, to do linear regression on the data on these tables.

The **Plot** menu provides commands to modify an existing plot or prepare a new plot of data in the parametric table.

The **Windows** menu provides a convenient method of bringing any of the EES windows to the front or to organize windows.

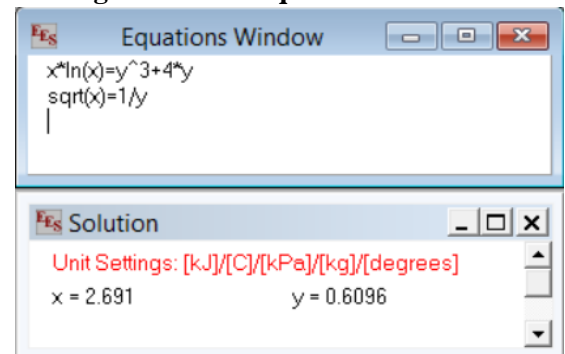
The **Help** menu provides commands for accessing the online help documentation.

## 1.3. Getting Started

### 1.3.1. Mathematical and EES operations

Math. Operations	EES Operations
Multiplication	*
Division	/
Subtraction	-
Parenthesis	( )
Brackets	[ ]
Square root	sqrt( )
Power	^
Natural logarithm	ln( )
Efficiency, epsilon	eta , epsilon
Subscript	Shift -
Sine, tan, cosine	sin( ),tan ( ), cos( )

### 1.3.2. Solving Non-linear equation





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### 1.1.1. Thermodynamic Properties

**Equations Window**

```
P1=2000
T1=489
h1=enthalpy(water,T=T1,P=P1)
s1=entropy(water,T=T1,P=P1)
v1=volume(water,T=T1,P=P1)
u1=intenergy(water,T=T1,P=P1)
C_p=cp(water,T=T1,P=P1)
```

**Solution**

Unit Settings: [kJ]/[C]/[kPa]/[kg]/[degrees]

C<sub>p</sub> = 2.205 [kJ/kg-K]      h1 = 3443 [kJ/kg]

P1 = 2000                      s1 = 7.4 [kJ/kg-K]

T1 = 489                        u1 = 3097 [kJ/kg]

v1 = 0.173 [m<sup>3</sup>/kg]

Calculation time = .0 sec

**Equations Window**

```
T1=500
P2=500
h1=enthalpy(R$,P=P1,T=T1)
h2=h1
T2=temperature(R$,h=h2,P=P2)
```

**Parametric Table**

Table 1	Table 2
1..10	P1      T2 [C]
Run 1	10000      480.3
Run 2	10500      479.4
Run 3	11000      478.5
Run 4	11500      477.6
Run 5	12000      476.8
Run 6	12500      475.9
Run 7	13000      475.1
Run 8	13500      474.3

### 1.1.3. Window diagram, Input & Output, and String Data

**Equations Window**

```
P1=1000
T1=500
P2=500
h1=enthalpy(R$,P=P1,T=T1)
h2=h1
T2=temperature(R$,h=h2,P=P2)
```

**Diagram Window**

Calculate      Print      Help

h1 = 3479 [kJ/kg]      T2 = 497.5 [C]

R\$= R12

Water

R11

R12

Fig.1.1. Throttle Valve

For making Arrays tables, you should use the square brackets [ ] for each properties.

### 1.1.4. Parametric and Arrays Tables

Parametric tables are employed to enter multiple runs. Arrays tables are utilized to show the outputs in the separated columns.

**Equations Window**

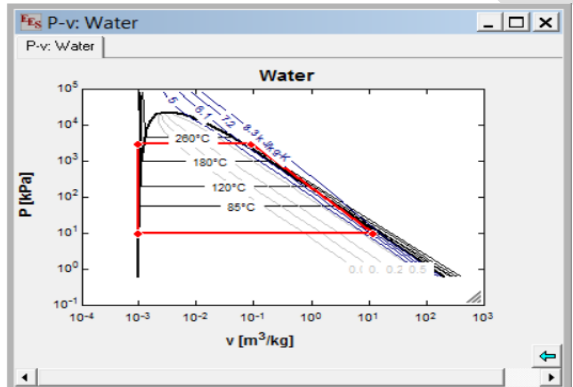
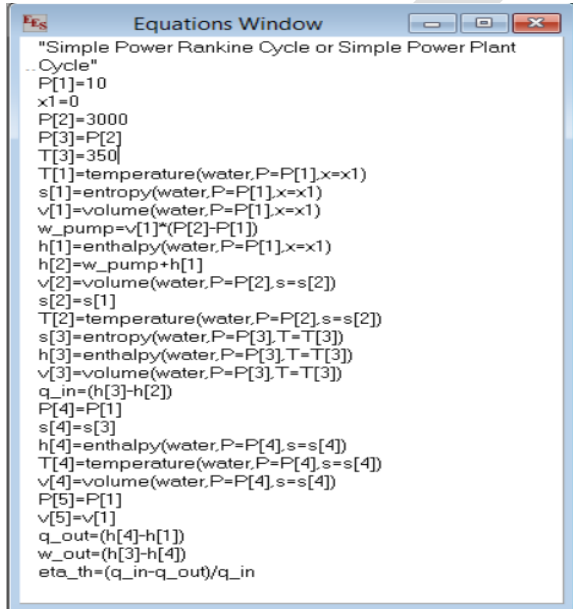
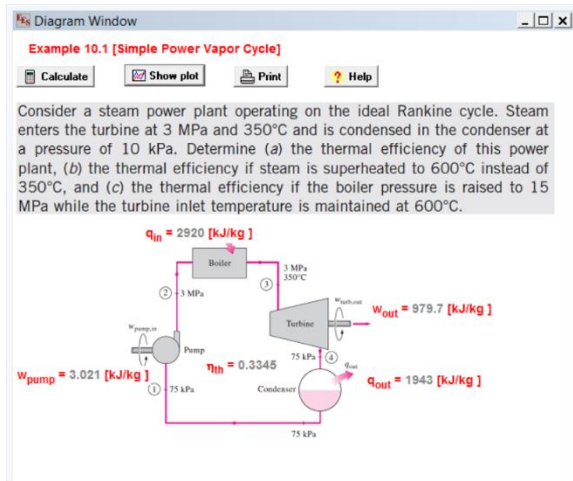
```
P[1]=1000
T[1]=500
P[2]=500
h[1]=enthalpy(R$,P=P[1],T=T[1])
h[2]=h[1]
T[2]=temperature(R$,h=h[2],P=P[2])
```

**Arrays Table**

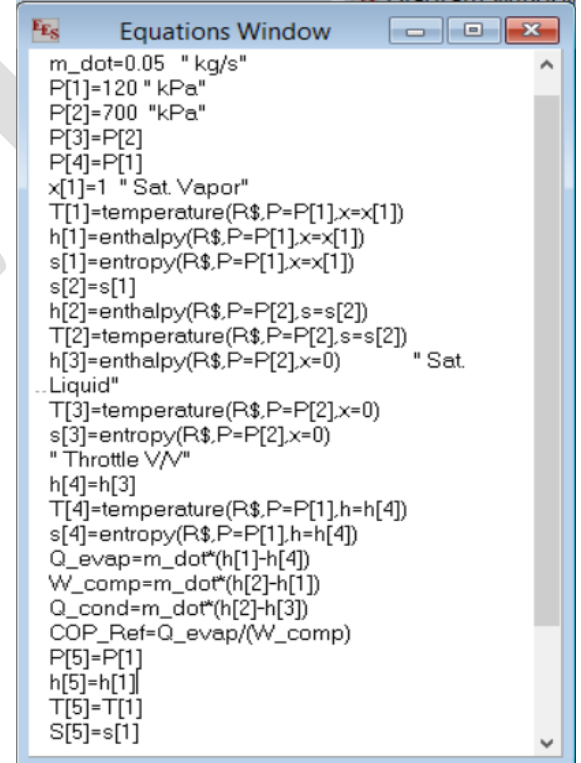
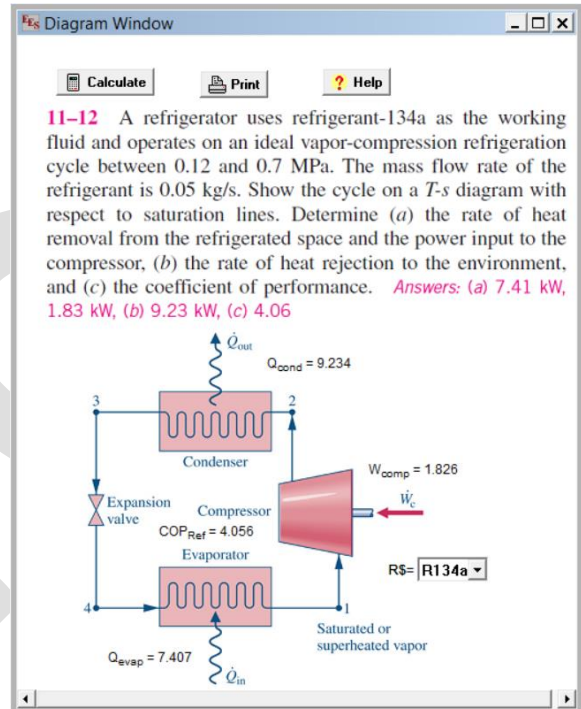
	1      h <sub>i</sub> [kJ/kg]	2      P <sub>i</sub>	3      T <sub>i</sub>
[1]	561	1000	500
[2]	561	500	498.9

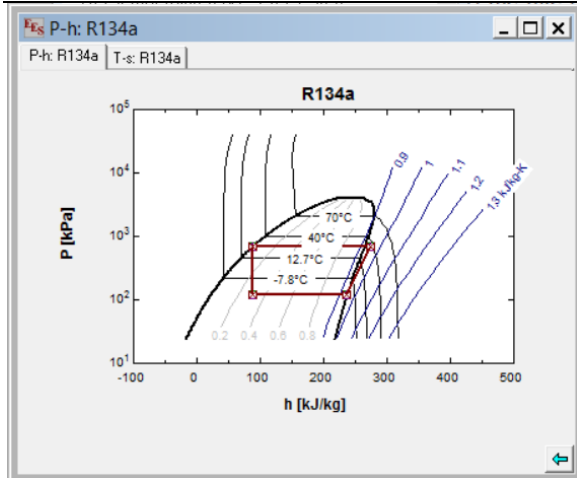
## 1.4. Applications

### 1.4.1. Power Plant Cycles



### 1.4.2. Refrigeration cycles

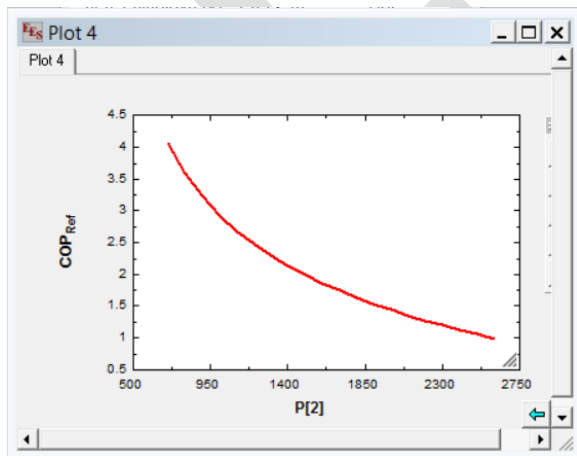




	1	2	3	4	5
	$h_1$ [kJ/kg]	$P_1$	$s_1$ [kJ/kg-K]	$T_1$ [C]	$x_1$
[1]	237	120	0.9478	-22.32	1
[2]	273.5	700	0.9478	34.95	
[3]	88.82	700	0.3323	26.69	
[4]	88.82	120	0.3572	-22.32	
[5]	237	120	0.9478	-22.32	

Table 1	Table 3	
1.20	$P_2$	$COP_{Ref}$
Run 1	700	4.056
Run 2	800	3.59
Run 3	900	3.226
Run 4	1000	2.931
Run 5	1100	2.684
Run 6	1200	2.474
Run 7	1300	2.292
Run 8	1400	2.132
Run 9	1500	1.989
Run 10	1600	1.86
Run 11	1700	1.743
Run 12	1800	1.635
Run 13	1900	1.536
Run 14	2000	1.444
Run 15	2100	1.357
Run 16	2200	1.276
Run 17	2300	1.2
Run 18	2400	1.127
Run 19	2500	1.058
Run 20	2600	0.9923

Using a parametric table to show if we change the maximum pressure that can be provided by the compressor, what does happen to the COP of the cycle?!!



**Fig.** The “COP” of R134a with various maximum pressure.

*May ALLAH reward you in this life and here after...*