EES Solution for Example Problem – Major and Minor Losses in a Piping System

Here is exactly what I typed into the main "Equations Window" of EES:

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"EES Solution for the class example problem - major and minor losses in a piping system
J. M. Cimbala, February 2005"

"Constants:"

h_L = 35 [m]
rho = 998 [kg/m^3]
mu = 1.00e-3 [kg/(m*s)]
D = 0.025 [m]
L = 20.0 [m]
SigmaK = 13.35

"Equations:"

h_L = (f*L/D + SigmaK)*(V^2)/(2*g#)   "Note that g# is the gravitational constant, pre-defined by EES"
Re = rho*D*V/mu
eps_by_D = 0.004
V_dot = V*PI*(D^2)/4

"Colebrook equation:"   1/sqrt(f) = -2.0*log10(eps_by_D/3.7 + 2.51/(Re*sqrt(f)))

"To solve, click on Calculate and then Solve. Note that it does not converge unless you change the limits and
guesses in Options-Variable Info"
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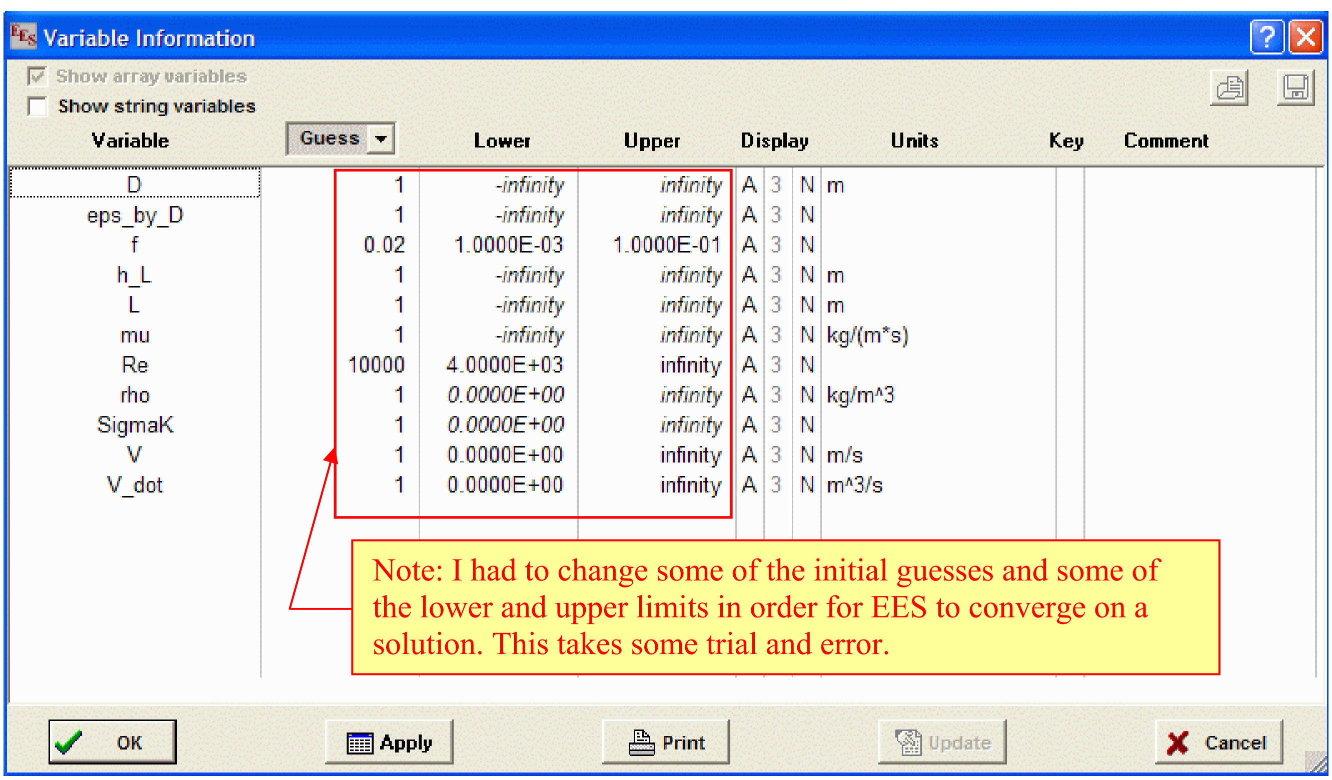
Note: We could have used the EES function "MoodyChart" instead of the Colebrook equation; i.e.,

f = MoodyChart(Re,eps_by_D)

Here is what the "Options-Variable Info" chart looks like:



Variable	Guess	Lower	Upper	Display			Units	Key	Comment
D	1	-infinity	infinity	A	3	N	m		
eps_by_D	1	-infinity	infinity	A	3	N			
f	0.02	1.0000E-03	1.0000E-01	A	3	N			
h_L	1	-infinity	infinity	A	3	N	m		
L	1	-infinity	infinity	A	3	N	m		
mu	1	-infinity	infinity	A	3	N	kg/(m*s)		
Re	10000	4.0000E+03	infinity	A	3	N			
rho	1	0.0000E+00	infinity	A	3	N	kg/m^3		
SigmaK	1	0.0000E+00	infinity	A	3	N			
V	1	0.0000E+00	infinity	A	3	N	m/s		
V_dot	1	0.0000E+00	infinity	A	3	N	m^3/s		

Note: I had to change some of the initial guesses and some of the lower and upper limits in order for EES to converge on a solution. This takes some trial and error.

The Formatted Equations window looks like this (the equations appear in much more readable format):

Formatted Equations

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Constants:

$h_L = 35$ [m]

$\rho = 998$ [kg/m^3]

$\mu = 0.001$ [kg/(m*s)]

$D = 0.025$ [m]

$L = 20$ [m]

$SigmaK = 13.35$

Equations:

$$h_L = \left[f \cdot \frac{L}{D} + SigmaK \right] \cdot \frac{V^2}{2 \cdot 9.807 \ [m/s^2]}$$ Note that g# is the gravitational constant, pre-defined by EES

$$Re = \rho \cdot D \cdot \frac{V}{\mu}$$

$$eps_{by,D} = 0.004$$

$$\dot{V} = V \cdot \pi \cdot \frac{D^2}{4}$$

Colebrook equation: $$\frac{1}{\sqrt{f}} = -2 \cdot \log\left[\frac{eps_{by,D}}{3.7} + \frac{2.51}{Re \cdot \sqrt{f}} \right]$$

To solve, click on Calculate and then Solve. Note that it does not converge unless you change the limits and guesses in Options-Variable Info

Finally, Calculate and Solve yields the solution:

D=0.025 [m]
eps_by_D=0.004
f=0.02943
h_L=35 [m]
L=20 [m]
mu=0.001 [kg/(m*s)]
Re=107627
rho=998 [kg/m^3]
SigmaK=13.35
V=4.314 [m/s]
V_dot=0.002117 [m^3/s]

This is our final result, i.e., the volume flow rate through the pipe. We can verify that all the variables are correct, and are the same as those calculated by "hand", i.e.,

V_dot = 2.12×10^{-3} m^3/s.