Homework 15

Ch En 263 – Numerical Tools

Due date: 28 May 2020

Instructions

- For the handwritten problems, submitted a single pdf file on Learning Suite with the name "LastName_FirstName_HW15.pdf".
- For the problems in Excel, submit a workbook named "LastName_FirstName_HW15.xlsx" where each worksheet tab is named "Problem_1", "Problem_2", etc.
- For the problems in Python, submit a separate file for each problem named "LastName_FirstName_HW15_ProblemXX.py" where XX is the problem number.
- **Please report how long it took you to complete the assignment (in hours) in the "Notes" section on Learning Suite.**

Problems

1. Find a valid solution to the nonlinear system

$$x^2 - 2x + 3y = 4$$
$$x^2 - 2y = 2$$

   using the optimization tool (Solver) in Excel.

2. The equations below come from a kind of vapor-liquid equilibrium problem that you will solve in your Thermodynamics class.

$$x_1 10^{A_1 - B_1/(T+C_1)} = p_1$$
$$(1 - x_1) 10^{A_2 - B_2/(T+C_2)} = p_2$$

   In these problems, one has a mixture of two chemicals (e.g. ethylbenzene and toluene) that are partially liquid and partially vapor. x_1 is the mole-fraction of species 1 in the liquid, $x_2 = 1 - x_1$ is the mole-fraction of species 2 in the liquid, T is the temperature in °C, p_1 is the partial pressure of species 1 in the vapor, p_2 is the partial pressure of species 2 in the vapor and A_1, B_1, C_1, A_2, B_2, C_2 are Antoine Coefficients for species 1 and 2 respectively.

   Given that $p_1 = 250$ mmHg, $p_2 = 343$ mmHg, $A_1 = 6.95719$, $B_1 = 1424.255$, $C_1 = 213.21$, $A_2 = 6.95464$, $B_2 = 1344.8$, $C_2 = 219.48$, use Scipy's `minimize` function to find the mole-fraction x_1 and the temperature T in °C.

   Hint: Don't worry about messing with the units for this problem; they are kind of screwy in these "flash" problems because of the $10^{A-B/(T+C)}$ part. If you just plug in the numbers I've given you, they will work out.

3. Use Excel's Solver to solve the Colebrook equation for the friction factor, f

$$\frac{1}{\sqrt{f}} = -2\log_{10}\left(\frac{\epsilon/D}{3.7} + \frac{2.51}{\mathrm{Re}\sqrt{f}}\right)$$

   when $\epsilon = 0.025$ mm, $D = 50$ mm and $\mathrm{Re} = 25000$. *Hint: From physical intuition (in a class you will take in the future!) one knows that f will greater than 0 and smaller than 1.*

4. Use Scipy's `minimize` function to find the solution to the following system of equations:

$$x_0 x_1 x_2 - x_0^2 + x_1^2 = 1.34$$
$$x_0 x_1 - x_2^2 = 0.09$$
$$e^{x_0} - e^{x_1} + x_2 = 0.41.$$