Homework 13

Ch En 263 – Numerical Tools

Due date: 26 May 2020

Instructions

- For the handwritten problems, submitted a single pdf file on Learning Suite with the name "LastName_FirstName_HW13.pdf".
- For the problems in Excel, submit a workbook named "LastName_FirstName_HW13.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_HW13_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. In this problem we are going to find the roots of function

$$x^2 - \frac{8}{3}x + \frac{3}{2} = 0$$

using both Picard's method and Newton's method in Excel.

   (a) Plot the function in the range $x \in [0, 3]$. Use your plot to find approximate values for the two roots of the function. These will be your starting guesses for parts (b) and (c).

   (b) Use Picard's method to find one of the roots of the function. Let the cell at the top of the column be your guess value $x^{(0)}$. Evaluate $g(x^{(0)})$ in the row below, $g(x^{(1)})$ in the next row, and so on until the value converges to the root. Highlight the cell with the root so that the grader can easily locate it.

   (c) Use Newton's method to find the other root in an additional column. Follow the same procedure as with Picard's method, but use the $g(x)$ function appropriate for Newton's method. Again, highlight the cell with the converged value so that the grader can easily locate it.

2. To find the power required to pump a fluid through a pipe we need a quantity called the fraction factor. The friction factor is found from an empirical correlation called the Prandtl-Karman equation,

$$\frac{1}{\sqrt{f}} = 4 \log_{10}\left(Re\sqrt{f}\right) - 0.4$$

where f is the dimensionless friction factor and Re is a dimensionless number called the Reynolds number. Write a Python code that uses Newton's method to solve for f when $Re = 10^4$. A good guess is $f \approx 0.005$.

3. The Redlich/Kwong Equation of State is

$$P = \frac{RT}{V-b} - \frac{a}{T^{1/2}V(V+b)},$$

where T is temperature, V is molar volume, R is the universal gas constant, a and b are compound-specific constants. The roots of this cubic equation give the molar volume of a liquid and vapor phase in equilibrium. Write a Python code to find the molar volume of both the liquid and vapor phase of ethane that is present at $T = 77\ ^o\text{C}$ and $P = 1$ bar. For ethane, $a = 2.877 \times 10^8$ cm^6 bar K$^{0.5}$ mol^{-2} and $b = 60.211$ cm^3 mol^{-1}. Print the value of both molar volumes to the console.

Hints: You should convert T to an absolute temperature scale, i.e. K. Use the ideal gas law to get a guess for the vapor volume, and use $1.1b$ *as a guess for the liquid volume. By the way, there is another root in between that of the vapor and liquid that is not physical.*