Homework 8

Ch En 263 – Numerical Tools

Due: 11 Mar. 2024

Instructions

- Complete the problems below and submit the following files to Learning Suite:
 - Handwritten portion: scan each page (or take a picture) and combine them into a single pdf named: LastName_FirstName_HW8.pdf
 - Excel portion: submit a workbook named LastName_FirstName_HW8.xlsx where each worksheet tab is named "Problem_1", "Problem_2", etc.
 - Python portion: submit a separate file for each problem named LastName_FirstName_ HW8_ProblemXX.py where XX is the problem number.

Problems

1. 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. Use Newton's method in Excel to solve for f when $Re = 10^4$. A good guess is $f \approx 0.005$.

2. 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 using Newton's method to find the molar volume of both the liquid and vapor phase of ethane that is present at T = 77 °C and P = 1 bar. For ethane, $a = 2.877 \times 10^8$ cm⁶ bar K^{0.5} mol⁻² and b = 60.211 cm³ 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.

3. In this problem, we are going to find the *four* solutions for x and y to the following equations

$$2x^2 + y^2 = 1 (1)$$

$$(0.5x - 0.5)^2 + 2(y - 0.25)^2 = 1.$$
(2)

(a) Write out by hand the equations in standard, vector form f(x) = 0 where f_0 is Equation 1, f_1 is Equation 2, $x_0 = x$ and $x_1 = y$.

- (b) In Python, make a plot of the two equations with the variable y on the y-axis and the variable x on the x-axis. *Hint: Re-arrange Eq. 1 and Eq. 2 to solve for* y. *Remember that when solving* $y^2 = f(x)$ *for* y, *the solution is* $y = \pm \sqrt{f(x)}$.
- (c) Write a Python code to solve for the four roots using root-finding methods. Use the plot from part (b) for your initial guesses. Please print the converged values to the console, so the grader can easily locate them.