Homework 1

Ch En 263 – Numerical Tools

Due: 15 Jan. 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_HW01.pdf`
  - Excel portion: submit a workbook named `LastName_FirstName_HW01.xlsx` where each worksheet tab is named "Problem_1", "Problem_2", etc.
  - Python portion: submit a separate file for each problem named `LastName_FirstName_HW01_ProblemXX.py` where XX is the problem number.
- Warning: the LS assignment will close promptly at 11:59 pm and late assignments will only receive 50% credit.

Problems

1. Classify the following equations as single/system, coupled/uncoupled, linear/nonlinear, differential/integral/algebraic:

   (a)

   $$\frac{1}{\sqrt{x_2}} + 5\exp(x_2) = 0$$
   $$x_1 + 3x_1^2 + x_1^3 = 3$$

   (b)

   $$6x_1 + 2x_2 = 3$$
   $$x_1 + 3x_2 = \sin(\pi/3)$$

   (c)

   $$\left(\frac{dy}{dt}\right)^2 + 2y = 0$$

2. Find an analytical solution to the system of equations,

   $$11x_1 + 3x_2 = 41$$
   $$4x_2 + 2x_3 = 0$$
   $$3x_1 + 2x_2 + 7x_3 = 24$$

3. Classify the following equations as single/system, coupled/uncoupled, linear/nonlinear, differential/integral/algebraic:

(a)

$$\frac{dA}{dt} = -k_1 AB^2$$
$$\frac{dB}{dt} = -k_1 AB^2$$
$$\frac{dC}{dt} = k_1 AB^2$$

(b)

$$\begin{bmatrix} -2 & 4 & 3 \\ 1 & -4 & 5 \\ 6 & 8 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} -3 \\ 2 \\ 9 \end{bmatrix}$$

(c)

$$2x^{2/3} + y^{2/3} - 9^{1/3} = 0$$
$$\frac{x^2}{4} + \sqrt{y} - 1 = 0$$

4. Find the analytical solution for $\boldsymbol{x}$ to the matrix equation $\boldsymbol{Ax} = \boldsymbol{b}$ where

$$\boldsymbol{A} = \begin{bmatrix} 2 & 3 & 0 \\ -1 & 4 & -5 \\ 6 & 0 & 4 \end{bmatrix} \quad \text{and} \quad \boldsymbol{b} = \begin{bmatrix} -11 \\ -31 \\ 10 \end{bmatrix}$$

5. Use Python to write a program that asks for a dollar amount as input from the user and reports the value of a 12%, 15% and 18% tip. Print the amount of all three values to the screen and use logical operators to determine whether or not they exceed two dollars. (*Hint: You can use the function* `float()` *to turn a string into a float.*)

6. The Redlich-Kwong (RK) equation is more accurate than the Ideal Gas Law because it allows for molecular interactions at high pressures. The RK equation of state and the ideal gas law, are, respectively:

$$P_{RK} = \frac{RT}{V-b} - \frac{a}{V(V+b)\sqrt{T}}$$
$$P_{IG} = \frac{RT}{V}$$

Here, V is molar volume. Also,

$$a = 0.427 R^2 T_c^{2.5} / P_c,$$
$$b = 0.0866 RT_c / P_c,$$
$$R = 0.0821 \text{ liter-atm/(mol K)}.$$

(a) In an Excel workbook, evaluate P_{RK}, and P_{IG} for air for $T = 500$ K, $V = 5$ L/mol, $P_c = 37.2$ atm, and $T_c = 132.5$ K. Report the pressures in units of Pa. Format your worksheet to be readable and be sure to include units.

(b) Use Python to evaluate P_{RK}, and P_{IG} at the same conditions. Document your code with comments that include units and variable descriptions. For example:

```
P_c = 37.2 * 101325           # Critical pressure (Pa).
```

Use `print` statements to output the pressures like this:

```
The RK pressure is #### (Pa)
```