Homework 2

Ch En 263 – Numerical Tools

Due date: 30 Apr. 2020

Instructions

- For the problems in Excel, submit a workbook named "LastName_FirstName_HW02.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_HW02_ProblemXX.py" where XX is the problem number.
- Excel and Python template files are available on the course website.
- If needed, a supplmentary handwritten or typed document can be submitted via pdf on Learning Suite with the name "LastName_FirstName_HW02.pdf".
- Please report how long it took you to complete the assignment (in hours) in the "Notes" section on Learning Suite.

Problems

1. The rate of heat transfer (q) from a heated flat plate with a cool fluid stream flowing across it can be found by:

$$q = h\Delta T,$$

where h is the heat transfer coefficient and ΔT is the change in temperature between the cool fluid and the plate. The heat transfer is related to Nu, the dimensionless Nusselt number, through

$$\mathrm{Nu} = \frac{hL}{k} = 0.332\,\mathrm{Pr}^{1/3}\,\mathrm{Re}^{1/2},$$

where L is the plate length, k is the fluid's thermal conductivity, Pr is the dimensionless Prandtl number, and Re is the dimensionless Reynolds number. The last two quantities are given by

$$\mathrm{Re} = \frac{\rho L v}{\mu}, \qquad \mathrm{Pr} = \frac{\mu c_p}{k},$$

where μ is the fluid viscosity, c_p is the fluid heat capacity, v is the fluid velocity, and ρ is the fluid density.

(a) In an Excel worksheet, find the heat transfer rate in W/m^2 from a flat plate 2 m long and at T=343 K, if a stream of water passes over it at a velocity of 1.45 m/s. The temperature of the water is 294 K. The water properties are $\mu = 9.79 \times 10^{-4}\,\mathrm{Pa \cdot s}$, $\rho = 998\,\mathrm{kg/m^3}$, $k = 0.601$ W/(m K), and $c_p = 4.18 \times 10^3$ J/(kg K). Make sure you present the data so that it is readable.

(b) Find the same heat transfer rate using a Python code. Print your answer to the console so that the output looks like:

```
q = #### (W/m^2)
```

Hint: Begin by defining variables for all the known quantities, and then compute Nu. *h can be obtained once* Nu *is known.*

2. 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 both the amount of the 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.*)

3. 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,

$$a = 0.427R^2T_c^{2.5}/P_c,$$

$$b = 0.0866RT_c/P_c,$$

$$R = 0.0821 \text{ liter-atm/(mol K)}.$$

(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)
```