AM5801: Computational Lab
Assignment 8

Date: October 26, 2025

Deadline: November 1, 2025 Max mark: 50

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1. The *Redlich-Kwong* equation of state is given by

$$p = \frac{RT}{v-b} - \frac{a}{v(v+b)\sqrt{T}}$$

where
R = the gas constant [= 0.518 kJ/kg K],
T = absolute temperature (K),
p = absolute pressure (kPa),
v = volume of a kg of gas (m^3/kg).

The parameters a and b are calculated by

$$a = 0.427\frac{R^2 T_c^{2.5}}{p_c}, \qquad b = 0.0866R\frac{T_c}{p_c}$$

where $p_c = 4600$ kPa and $T_c = 191$ K. As a chemical engineer, you are asked to determine the amount of methane fuel that can be held in a 3 m^3 tank at a temperature of $-40°$C with a pressure of 65,000 kPa. Calculate the specific volume v and then determine the mass of methane contained in the tank using a root-locating method. Use initial guesses of $v = 0$ and $v = 2$ for the bracketing method. Perform iterations until the approximate relative error falls below 2%.

(15 marks)

2. In fluid mechanics, the *Reynolds number* (*Re*) determines whether a flow is laminar or turbulent. For flow through smooth circular pipes, the *Colebrook–White* equation relates the Darcy friction factor f to the Reynolds number Re and the relative roughness ε/D:

$$\frac{1}{\sqrt{f}} = -2.0\log_{10}\left(\frac{\varepsilon/D}{3.7} + \frac{2.51}{Re\sqrt{f}}\right)$$

This equation is *implicit in f* and cannot be solved directly, it requires an iterative numerical technique such as the Newton–Raphson method. You are tasked with determining the Darcy friction factor f for turbulent water flow through a pipe, given the following data:

Pipe diameter, $D = 0.05\,\text{m}$

Pipe roughness, $\varepsilon = 0.00015\,\text{m}$

Reynolds number, $Re = 2.0 \times 10^5$

Use an initial guess $f_0 = 0.02$ and perform iterations until the approximate relative error is less than 0.1%. Print iteration number, current estimate of f, and relative error in each iteration. Compare your result with the friction factor obtained from the explicit correlation:

$$f = \frac{0.25}{\left[\log_{10}\left(\frac{\varepsilon/D}{3.7} + \frac{5.74}{Re^{0.9}}\right)\right]^2}$$

(20 marks)

3. Consider the continuous function

$$y = x^2$$

defined over the interval $0 \leq x \leq 10$. The smooth curve of this function is to be replaced by a piecewise linear interpolation curve constructed from n equally spaced data points in x. For this interpolation, determine the maximum interpolation error within each segment and compare how the maximum error varies from one segment to another ($n + 1$ segments).

Extend the study by repeating the same for two higher and two lower values of n, thereby examining the effect of data spacing on interpolation accuracy. The variation of maximum error with the number of segments should be displayed graphically, and appropriate observations and conclusions regarding the influence of data density on the interpolation error should be presented.

(15 marks)