Homework 19

Ch En 263 – Numerical Tools

Due date: 9 Jun. 2020

Instructions

- For the handwritten problems, submitted a single pdf file on Learning Suite with the name "LastName_FirstName_HW19.pdf".
- For the problems in Excel, submit a workbook named "LastName_FirstName_HW19.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_HW19_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. Numerically evaluate the integral

$$I = \int_0^{2\pi} e^{-x} \sin(3x) dx$$

using the composite trapezoidal rule with $N = 101$ points in Excel.

2. In Python, write a function that uses the composite trapezoidal rule to compute the integral

$$I = \int_0^3 1 - \exp(-x)\, dx$$

for an arbitrary number of trapezoids n. Use your function to make a plot of I versus n for $n \in [2, 40]$. Include the exact result of the integral as a dashed line on the plot for reference.

3. In reaction engineering, the average residence time $\bar{t}$ is the amount of time an element of fluid spends in a reactor and is related to the amount of substance present in the system. The easiest method to determine $\bar{t}$ is via a pulse stimulus, where a small amount of a tracer is put into a reactor operating under steady state and the effluent concentration measured over time. The average residence time is calculated as

$$\bar{t} = \frac{\int_0^\infty tC dt}{\int_0^\infty C dt}$$

t (s)	C (ppm)
0	0
100	20
200	20
300	16
400	10
500	7
600	5
700	3
800	1
900	0

Given the data in the table, write a Python program to:

(a) Find and plot a cubic spline which interpolates the function $C(t)$, and

(b) Calculate the residence time $\bar{t}$ via the composite trapezoidal rule.

Hint: There are two integrals in part (b): one in the numerator and one in the denominator.