CH2013: Computational Programming and Simulations Lab
July-Nov 2023
Problem Sheet #2a

16 August 2023

1) **[For evaluation]** The temperature of a well mixed reactor is given by the roots of the equation

$$x = \delta e^{x}$$

   a) Use Newton Raphson method to solve for x for δ = 0.1. Here δ represents the heat of reaction. **[Grader]**
   b) Use Newton Raphson method to solve for x for δ = 2. Here δ represents the heat of reaction. If you can't solve, report first 10 iterations having initial guess as 0. **[Grader]**
   c) Plot the LHS and RHS as a function of x for x for δ = 0.1 and δ = 2. Comment on your results in (1a & b)

   Instructions on variable name for the solution, tolerance etc.., are given in Mathlab Grader

2) **[For evaluation]** Consider the following equation

$$f(x) = x - \delta\, e^{\left(\frac{x}{1+\varepsilon x}\right)}$$

Here x is the temperature of a 0^{th} order reaction, δ = 0.53 is the heat of reaction and ε = 0.245 is the activation energy.

   a) Plot the above equation from x = 1 to x = 7.
   b) How may roots does this equation have?
   c) Use Newton Raphson method with different initial guesses to get the roots. **[Grader]**
   d) Use Bisection method to find the root in the middle. **[Grader]**

   Instructions on variable name for the solution, tolerance etc.., are given in Mathlab Grader

3) **[For evaluation]** The Colebrook-White equation is used express the relationship between Darcy-Weisbach friction factor f, Reynolds number Re and pipe relative roughness ε/D_h. This equation is applicable when the pipe is entirely filled with fluid. The equation is defined as follows:

$$\frac{1}{\sqrt{f}} = -2\, log\left(\frac{\varepsilon}{3.71 D_h} + \frac{2.51}{Re\sqrt{f}}\right)$$

Here D_h is the Hydraulic Diameter, ε is the surface roughness. This specific adaptation is also instrumental in generating the renowned Moody's diagram, a visual aid that facilitates the assessment of flow characteristics within pipes of varying roughness and dimensions. You will see this in the fluid mechanics course later. Re is defined as

$$Reynolds\ Number\ (Re) = \frac{Density * Velocity * Diameter}{Viscosity}$$

a) Solve the equation using Newton Raphson to obtain friction factor for a rusted steel pipe whose surface roughness (ε) is 0.5 mm, Hydraulic Diameter D_h is 0.1 m. Velocity Range 0.0892 m/s to 8.920 m/s. Store the computed values of friction factor in an array named **ffsol**. This array should contain friction factor corresponding to 100 Reynolds number (use 99 equally spaced intervals) spanning from a velocity of 0.0892 m/s to 8.920 m/s. **[Grader]**

b) Find the Reynolds number corresponding to the friction factor 0.0335 store it in a variable named **resol**. You can use inbuilt MATLAB function fsolve for this question. **[Grader]**

c) Solve the equation using Newton Raphson by changing the friction factor to find the Reynolds number. Friction factor range is from 0.0376 to 0.0305. Save an array named **rearr** which should contain values of Reynolds numbers for friction factor (use 9 equally spaced intervals). Store the computed values of Reynolds number in an array named **rearr**. This array should contain Reynolds number corresponding to 10 friction factors (use 9 equally spaced intervals) spanning from velocity 0.0892 m/s to 8.9200 m/s.

d) Plot Friction Factor vs Reynolds number, in the aforementioned velocity range and friction factor range. For the data where velocity is changed use red solid line and for data where friction factor is changed use blue color filled round markers.

S.No	Physical Properties @ 25 °C	Values
1	Density of Water	997 Kg/m^3
2	Viscosity of Water	$8.891*10^{-4}$ Pa S

Instructions on variable name for the solution, tolerance etc.., are given in Mathlab Grader

4) Find the roots of the fourth order polynomial given below using Newton-Raphson method. A) Use different initial guesses. B) Use the same initial guess to find all the roots.

$$f(x) = x^4 - 6x^3 + 12x^2 - 10x + 3$$

Instructions on variable name for the solution, tolerance etc.., are given in Mathlab Grader