Department of Chemical Engineering, IIT Kharagpur

CH49019: CAPE Laboratory Autumn 2021

Assignment 1: Due on September 12, 2021

Email Your Assignment (pdf only) to

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1. The following Eigenvalue Equation is obtained during solution of an unsteady state diffusion equation by Separation of Variables.

$$\sin\lambda - \lambda\cos\lambda = 0$$

There are many roots for the above equation and $\lambda = 0$ is one of them. Find the smallest positve root by any numerial zero-finding method of your choice. Also, solve the problem using `fzero` function of MATLAB and compare two results in a table.

2. The well-known Colebrook-White equation for flow friction is an implicit equation.

$$\frac{1}{\sqrt{f}} = -2\cdot\log_{10}\left(\frac{2.51}{Re}\cdot\frac{1}{\sqrt{f}} + \frac{\frac{\varepsilon}{D}}{3.71}\right)$$

Determine the flow friction factor (f) for the following two cases using Bisection Method.

(i) $Re = 2.3 \times 10^5$ and $\frac{\epsilon}{D} = 10^{-4}$

(ii) $Re = 4.6 \times 10^7$ and $\frac{\epsilon}{D} = 0.037$

Also, solve the problem using `fzero` function of MATLAB and compare two results.

In literature, many explicit equations have been proposed to approximate the Colebrook-White implicit equation. Recently, Praks and Brkic (2020) have proposed the following relation.

$$\frac{1}{\sqrt{f}} = 0.8686\left(B - C + \frac{C}{X - 0.5564C + 1.207}\right)$$

where

$$X = A + B$$

$$A = \frac{(Re)\varepsilon}{8.0884D},\ B = \ln(Re) - 0.7794,\ C = \ln(X)$$

Determine the flow friction factor (f) for the above two cases using the explicit relation and report the Relative Error (%) compared with the implicit Colebrook-White equation. Present your results in the tabular form as follows:

	Friction Factor computed using Colebrook-White equation		Friction Factor computed using Explicit Relation (C)	Relative Error (%)
Case	Bisection Method (A)	`fzero` (B)		$\left\|\frac{C-B}{B}\right\| \times 100$
$Re = 2.3 \times 10^5$ $\frac{\epsilon}{D} = 10^{-4}$				
$Re = 4.6 \times 10^7$ $\frac{\epsilon}{D} = 0.037$				

<u>Optional Question</u>:

Write a program (preferably using `fzero` of MATLAB) to generate Moody Chart for friction factor.

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