Pak-Austria Fachhochschule Institute of Applied Sciences and Technology

Lab Project

Numerical Computations Fall 2024

Maximum marks: 50 **Due by December 05, 2024**

Registration no. _____ **Name** _____

Section _____ **Instructor: Dr. Muhammad Tayyab**

Project Title: Solving Fluid Flow in a Pipe Network using Numerical Methods

Overview:

Fluid flow in a pipe network is crucial in engineering applications, such as water distribution systems and gas pipelines. Similar to electrical grids, these networks can be represented by a set of non-linear algebraic equations governing the flow and pressure at various nodes. In this project, develop a mathematical model for a simple two-node pipe network and solve it using Newton's method.

Objectives:

1. Model fluid flow and pressure loss across a two-node pipe network.
2. Write the non-linear equations representing the system.
3. Solve these equations numerically using Newton's method.
4. Analyze convergence behavior with different initial guesses.

Project Steps:

1. **Model Formulation**:
   - Consider two nodes connected by a pipe with flow Q and pressure loss ΔP.
   - Assume
     - Pressure at the supply node $P_s = 100$ psi (constant).
     - Pressure at the receiving node P, which needs to be calculated.
     - Flow rate Q related to $\Delta P = P_s - P$ using the formula:

$$Q = K\sqrt{\Delta P},$$

       where K is a flow coefficient depending on pipe characteristics.
2. **Derive Equations**:
   - Convert the flow equation into a set of algebraic equations: $f(P) = 0$, to solve for pressure P.
   - Use initial values for P and set a tolerance $\epsilon = 10^{-6}$.
3. **Numerical Solution**:
   - Implement Newton's method to solve for P numerically.
   - Choose an initial guess $P_0 = 90$ psi and tolerance $\epsilon = 10^{-6}$.
4. **Code Implementation**:
   - Write a Python/Matlab code to implement Newton's method.
   - Conduct tests with different initial guesses to observe convergence behavior.
5. **Extension Task**:
   - Vary the flow coefficient K and find the maximum K value at which Newton's method stops converging.

[2] 6. **Report Requirements**:

- Document the model derivation, steps of the numerical method, code, results, and conclusions.
- Attach the code and present all findings in a report of no more than five pages.
