AE618A: Finite Element Methods for Fluid Dynamics
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Assignment - 1

A. Consider a flow in which the velocity field is given as:

$$v_\theta = \frac{5}{r}, \tag{1}$$

$$v_r = 0. \tag{2}$$

This corresponds to a flow due to free vortex and results in circular streamlines. Trace, numerically, the trajectory of a fluid particle released at $r = 1$ and $\theta = 0$ by following the procedure described below:

1. Write equations for $\dot{\theta}$ and $\dot{r}$. Find the analytical solution.
2. Employing the basic Euler method solve the differential equations in cylindrical/polar coordinates. Utilize a computer program and plot your results. Carry out the computations for several revolutions of the particle. Compare the results for various values of Δt. For example, for $\Delta t = 1.0$, 0.1, 0.01, 0.001.
3. Repeat the above step for the improved Euler Method.
4. Comment on the relative accuracy of the two methods and the effect of time step.

B. Repeat the above computations in Cartesian coordinates.

C. Write a subroutine to solve a linear equation system: $\mathbf{A}\ \mathbf{x} = \mathbf{b}$. Check it out by solving for a test problem and submit the test only (and not the source code). You may use any method to solve the equation system (including NAG libraries).

Kindly do not e-mail your solutions. They need to be submitted on the portal by the deadline. No e-mail submissions will be accepted.