Problem\_Set\_5

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AE/ME8112 - Comp Fluid Dyn/Heat Transfer

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**Problem\_Set\_5 Questions**

1. laminar gaseous flow through a cylindrical pipe of length, *L* and radius *R* with a centerline axial velocity of *CLVZ*.

A screenshot of a cell phone

Description automatically generated

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# Question\_1

## Part a)

Since the flow is axisymmetric, the problem can be solved as a 2D flow in r and z. Figure ‎1.1 illustrates shchematic of our geometry.

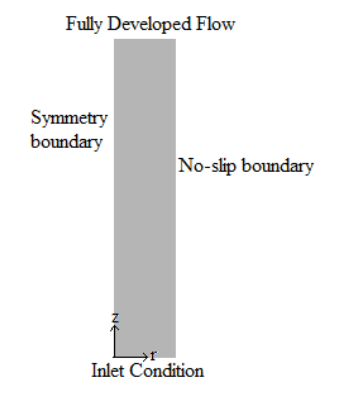


Figure ‎1.1- Shchematic of 2D geometry

**Assumptions:**

* Axisymmetry
* Constant density
* Constant viscosity
* Fully developed flow at the outflow

Based on these assumptions, the vorticity-velocity equations can be defined as :

|  |  |  |
| --- | --- | --- |
| vorticity transport: |  | (‎1.1) |
| Poisson radial velocity: |  | (‎1.2) |
| Continuity: |  | (‎1.3) |

In this section, an explicit finite difference discretization of above equations will be derived :

### Vorticity

In order to solve vorticity, we have:

|  |  |
| --- | --- |
|  | (‎1.4) |

Now with writing explicit finite difference discretization for time (forward) and space (central) we have:

* Middle points:

|  |  |
| --- | --- |
|  | (‎1.5) |
|  | (‎1.6) |

* Inflow:

|  |  |
| --- | --- |
|  | (‎1.7) |
|  | (‎1.8) |

* Wall:

|  |  |
| --- | --- |
|  | (‎1.9) |
|  | (‎1.10) |

* Outflow:

|  |  |
| --- | --- |
|  | (‎1.11) |
|  | (‎1.12) |

* Centerline:

|  |  |
| --- | --- |
|  | (‎1.13) |
|  | (‎1.14) |

### Radial Velocity

In order to solve radial velocity, we have:

|  |  |
| --- | --- |
|  | (‎1.4) |

Now we should write finite difference discretization for above equation.

* Middle points:

|  |  |
| --- | --- |
|  | (‎1.4) |

|  |  |
| --- | --- |
|  | (‎1.4) |

* Inflow, wall, and centerline:

|  |  |
| --- | --- |
|  | (‎1.7) |
|  |  |

* Outflow:

|  |  |
| --- | --- |
|  | (‎1.11) |
|  | (‎1.12) |

### Axial velocity

In order to solve radial velocity, we should use continuity equation:

|  |  |
| --- | --- |
|  | (‎1.4) |
|  | (‎1.4) |

Now we should write finite difference discretization for above equation.

* Middle points:

|  |  |
| --- | --- |
|  | (‎1.4) |
|  | (‎1.4) |

* Inflow:

is parabolic, decreasing from clvzat the centerline to 0 at the wall.

|  |  |
| --- | --- |
|  | (‎1.8) |

* Wall:

|  |  |
| --- | --- |
|  | (‎1.9) |

* Outflow:

|  |  |
| --- | --- |
|  | (‎1.11) |
|  | (‎1.12) |

* Centerline:

|  |  |
| --- | --- |
|  | (‎1.11) |
|  | (‎1.12) |

## Part b)

C++ code:

|  |
| --- |
|  |

Output :

## Part c)

## Part d)

# References

Use the "Insert Citation" button to add citations to this document.