

A Projection based 2D Incompressible Navier-Stokes solver with comparative Poisson Methods.

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February 4, 2026

Proposal

I will implement a 2D incompressible Navier–Stokes solver on a Cartesian grid using a projection method. In each timestep, the solver will first compute an intermediate velocity using advection and viscosity and then it will enforce incompressibility by solving a pressure Poisson equation. I plan to make it divergence free by correcting the velocity by making use of some helper function. The main goal is to implement and compare two Poisson solvers used for the pressure step i.e., Jacobi and Gauss–Seidel using the same grid, timestep, and stopping tolerance. I will measure the convergence of each method, runtime per timestep and how cost scales with grid sizes of 32×32 , 64×64 and 128×128 respectively. I will keep things simple and use a lid driven cavity problem to validate my solver. The solver will output the velocity and pressure fields and compare these profiles to published benchmark data.

References

- [1] A. J. Chorin, “Numerical solution of the Navier-Stokes equations,” *Mathematics of Computation*, 1968.

I chose this paper because this is the foundational source for the projection method idea that leads to a Poisson solve during each timestep.

- [2] Y. Saad, “Iterative methods for sparse linear systems,” *Textbook*, 1996.

I will mainly use this book for referencing to the Jacobi and Gauss-Siedel step. This book also contains the stopping criteria for the Poisson solve that I will use in my solver.

- [3] C. T. S. U. Ghia, K. N. Ghia, “High - Re solutions for incompressible flow using the Navier-Stokes equations and a multigrid method,” *Journal of Computational Physics*, 1982.

I chose this paper because this contains benchmark data for validation for lid-driven cavity problems. I will use the data from here to validate my solver.