SDS 335 Project Proposal
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Our topic covers simulating a fluid dynamical system using Monte Carlo techniques. The topic will require much understanding of fluid mechanics. Equations of motion and energy are needed to help "see" how the system behaves. In fluid mechanics these are known as Navier-Stokes equations because they describe the motion of viscous fluid substances. Along with physically understanding gradients and partial derivatives in regards to Navier-Stokes, we must also learn to effectively discretize these equations in order to put into the computer and get a result. We will also need to determine the linearity of these equations. Non-linear equations require more sophisticated numerical methods in order to solve because there is no simple solution. Another important factor to consider is initial conditions. If we have non-linear equations governing the motion then any change in the starting parameters can lead to completely different behavior by the system.

The project will be written in C and compiled using the intel compiler; we are entertaining the possibility running parts in parallel using MPI where possible. We will research existing implementations of this simulation, potentially making our own modifications where we believe the code can be improved, or run in parallel for a better use of computational time. Math libraries such as LAPACK and BLAS will be useful for the Monte Carlo calculations within the matrix. Given time, we also intend to include restart capability from saved simulation profiles.

Armed with various Monte Carlo techniques for sampling, we will try each of these methods to determine whether one is a better physical model for the given process. Also, running multiple types of simulations will allow us to cross-check them and see if the methods gives consistent results when compared to each other. After running all these types, we intend to write our own variation on a method that builds off the others, and check it against data and the other existing methods to test its reliability.

In addition to using different computational techniques for the simulations, we also intend to apply our chosen set of methods to various physical scenarios where the general fluid dynamics equations hold. For example, we could apply our code to flow in stellar interiors, paths in plasma, or motion of condensed matter. Each would require accessory equations, and would only be a model that is simple enough to work with at our undergraduate level, but useful enough to be nontrivial for research applications.