**Possible Project Topics for AMSC/CMSC 763**
Advanced Numerical Linear Algebra
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The goal of the class project is to take a topic from the class curriculum and to explore its use in a computational study. Some options for how to go about this include:

**1. Explore preconditioning strategies.** For a problem of your choice, develop a preconditioning algorithm for use with Krylov subspace methods and compare its performance with a "standard" preconditioner such as incomplete LU factorization.

**2. Multigrid.** Implement your own multigrid algorithm for solving a discrete partial differential equation, and demonstrate that it behaves the way it is supposed to, i.e., it exhibits grid-independent convergence. Compare different variants of the algorithms, for example, choice of smoother, choice of grid-transfer operators, type of cycle.

**3. Eigenvalue methods.** Implement the Lanczos algorithm for computing the eigenvalues of a large symmetric matrix, and explore the impact of roundoff error on performance. Examine the orthogonality of the vectors computed and explore ways to reduce the effects of floating point errors.

**4. Performance of Krylov subspace methods.** We studied the GMRES method for non-symmetric linear systems, but there are cost issues associated with it that are avoided by other methods. Some of these alternatives are the BiCG, BiCGSTAB, and IDR methods, as well as restarting GMRES. Examine the literature on this topic, implement some of these methods (at least three) and compare their performance on some benchmark problems.

**5. Parallel / GPU / Multicore Implementation.** If you have access to a computer with special architectural features, test the performance of a method of your choice on it and examine how to enhance its efficiency for the specific machine you are using.

For any of these, you will have to choose a benchmark problem or a series of them. This can be done by using one you have access to in your own research, constructing your own using finite differences for a partial differential equation, getting one (or more) from the "matrix market" repository

`http://math.nist.gov/MatrixMarket/` ,

using examples from my IFISS software package,

`http://www.cs.umd.edu/ elman/ifiss/index.html`,

or from other sources that you may know.

In addition, you will need to do some independent reading to flesh out material covered in class. For example, you would want to explore how roundoff error affects eigenvalue computations or what variants of multigrid there are.