21-344: Numerical Linear Algebra
Expectations for the Course Project

Your course project in this class will consist of (1) a **report**, in the style of an academic journal article, on the project, and (2) a **presentation** about the project that you will deliver to the rest of class (and any others who might be interested in attending). Projects will focus on topics beyond the standard curriculum of the course, in one or more of the following ways:

- The project will explore the application of concepts and techniques from numerical linear algebra to a topic of interest to the student.
- The project will explore a topic or technique in numerical linear algebra that we have not covered in class.
- The project will explore some recent advance in the field of numerical linear algebra.

Each project should contain the following, at a minimum:

- A detailed discussion of the topic at the center of the project, with references to supporting materials.
- The type and characteristics of linear systems that arise in the application area, or are the focus of the topic/new technique.
- Some coding component, whether it be to code some new method/technique, or to explore solver behavior for linear systems of the type in question, or to run numerical experiments to assess the performance of an existing method or technique.

The problem of interest can be virtually anything you might be interested in, as long as you can relate it to numerical linear algebra. It is **not** a requirement that your project be original research, however if it is, then you stand to benefit greatly (now and in the future) from putting in a large amount of effort into the project.

Expectations for the Project Report: The project report should be a typeset document (final draft in PDF format) that satisfies the following criteria:

- It should be at least 5 pages in length, not including references and any associated codes.
- Equations, tables, and figues that are cross-referenced in the text should be labeled and cited. In LaTeX you should be using `\label{}` and `\ref{}` or `\eqref{}`.
- Figures and tables should have captions.
- There should be a bibliography with at least three references that are cited in the text. There must be at least two non-wikipedia type references (i.e., you should cite at least 2 papers/books). In LaTeX you should be using `\cite`.

Some things to note about your report:

- It is not necessary to contain any original research done by you, i.e., it is acceptable if the document is a review or survey of existing research/methods for a problem.
- The best way to learn how to write journal articles is to read lots of journal articles.

- Your report should have an introduction, a main body, and a summary section at a minimum.
- Having multiple references will be useful - it is easier to put together the pieces in your head if you have more than one resource for a particular problem.

Expectations for the Project Presentation: The project presentation will take place during the final exam period, which will be Friday, May 14th, from 1:00pm to 4:00pm. Your PDF slide presentation will be given via computer projector (either using your own computer or the instructor's). Your presentation should be between 4 and 7 minutes in duration, with a goal of 5-6 minutes. If you are not familiar with constructing presentations via LaTeX but wish to use it, the `beamer` class provides easy-to-use templates and has substantial documentation. Some things to note about your presentation:

- Try to allow up to one minute per slide - so ideally your talk should not have more than 6-8 slides (not including title, etc.).
- Don't put too much text on a slide - you don't have to write in complete sentences as long as you simply don't read off of your slides (generally a bad idea).
- Figures and tables should be presented so that the audience can actually see the important information. Avoid tiny text in captions, labels, tables, etc.
- Don't worry about getting too fancy with colors - dark text on a light background is the best setup for viewing.

Due Dates and Times:

- You need to turn in a statement of your **project topic** and what you plan to do with it no later than 11:59pm on Friday, April 9th, 2021.
- You need to turn in a **detailed outline of your project report** no later than 11:59pm on Friday, April 30th, 2021. The outline can change, but you at least need to demonstrate that you have planned what the report's content will be.
- You need to turn in the **final draft of your project report and your project presentation** no later than 8:30pm on Friday, May 14th, 2021. I will be comparing your final draft to the information you present during the project presentation.

Other Suggestions:

- You may work in groups of up to 2 or 3 if you like. If you do work with t least one other person, your report must be at least 8 pages (not including references and codes), and your presentation must be between 8 and 12 minutes in length, with a goal of around 10 minutes.
- Try to find as much existing work in the area of your problem as possible. Part of your report should be a review of any existing work on this type of problem. This is usually done in the introductory section.
- At any time I am happy to help you with any aspect of the project, from selecting a topic, to finding references, to helping with coding, to helping you interpret results.

Some Possible Project Ideas:

- Any application area where large linear systems must be analyzed or solved, such as image processing, bioinformatics, statistical analysis, feature identification, artificial intelligence, data mining, scientific research, etc.

- The use of numerical linear algebra in different aspects of machine learning or support vector machines, etc.
- How ranking systems, such as Google's Page Rank, construct large linear systems, and how their eigenvectors are found.
- Numerical techniques for indefinite or saddle-point linear systems.
- Numerical techniques for large sparse linear systems with nonzero (sparsity) patterns of certain types, including graph algorithms for sparse matrices.
- The use of linear systems in large-scale optimization problems, such as quadratic programming, etc.
- Existing specialized software libraries for linear systems of certain types.
- Applications of Principal Component Analysis that involve linear systems.
- Algorithms for finding a basis for the null space of a large singular matrix.
- Numerical techniques for solving systems with stochastic matrices or Markov Chains.
- Preconditioning techniques for linear systems that arise in different application areas.
- Uses of numerical linear algebra in the solution of systems of nonlinear equations.
- Properties of linear systems that arise in the numerical solution of partial differential equations.
- Linear algebra problems that arise in different areas of computational finance.
- Linear solvers for problems posed in finite fields.
- Non-negative matrix factorization (NMF).
- Any iterative or direct method that we have not covered in class, including enhancements to existing methods.