Student Project, APPM 3310 — Spring 2010
Final Project due dates: March 12$^{\text{th}}$, April 9$^{\text{th}}$, and April 26$^{\text{th}}$

We have studied some of the foundations of linear algebra and have hinted at different types of applications. In this project, choose an application of matrix methods (of interest to you!) and prepare a paper on this topic. The goal is for you to learn how matrix methods play a role in some topic of your interest. Some possible topics (in no particular order) include:

1. Graphs and incidence matrices from section 2.6.
2. Image compression. This is a huge area of active research, but it is fundamentally a problem in linear algebra. If you are interested in this, you will need to restrict to a specific subtopic.
3. There are many "named" matrix families. These include: Hadamard, Hankel, Hilbert, Magic, Pascal, Rosser, Toeplitz, and Vandermonde. You can investigate one of these families—applying many of the techniques that we are learning—and their application.
4. Springs and masses in section 6.1.
5. Electrical networks in section 6.2.
6. Structures in sections 6.3 and 9.5.
7. Additional topics in chapters 9 and 11.
8. Linear programming. (This is a huge area, you'll need to restrict to one small set of examples.)
9. Network models and spanning trees—such models are important for an understanding of the internet, of power distribution (and blackouts), etc.
10. Linear economic models.
11. Wavelets are based on matrix methods. You might investigate the Haar wavelet family. There are several "introductory" texts on wavelets, including *Discovering Wavelets* by Edward Aboufadel and Steven Schlicker.
12. The vector space model is fundamental to a basic understanding of search engines. *Understanding Search Engines* by Michael Berry and Murray Browne. is a place to start.
13. The fast Fourier transform (FFT) is a mainstay in computational linear algebra. One place to learn more is section 5.7.

These topics are not exhaustive. Consult with your instructor and choose a topic that you are interested in!

The paper will proceed in three steps. The first part will be a 2-page project proposal (Due March 12$^{\text{th}}$). The project proposal will include an introduction to your topic, some background information, and an outline of what you will cover in your paper. The second part will be a rough draft (Due April 9$^{\text{th}}$) and the third part will be the final paper (Due April 26$^{\text{th}}$).

Your project will be written in a manner similar to a research or journal article. It should be typewritten, although lengthy derivations can be handwritten and included in an appendix. Your paper should not be a random collection of facts. You should identify at least one specific question/problem. The goal of your paper is to answer that question. Therefore, the problem choice, mathematical development and explanation of the problem is very important. You should try and get a "big picture" view of what you are trying to accomplish with your project.

Your paper should have the following sections:

Abstract A short (1-2 paragraphs) summary of your problem and results. After reading your abstract, the reader should have an idea of the topic of your paper and what you accomplish in your paper.

Introduction: This section serves to introduce your topic and provide any background information. Include a survey of other people's work and/or a short discussion of the existing literature, as appropriate. Provide all necessary definitions and concepts for me (assume the reader is ignorant of your particular application) to understand the question you are studying. Provide references as appropriate. (This section may be anywhere from 2-5 pages long.) State explicitly what you are planning to do in the upcoming sections of the paper.

Model development/mathematical formulation: This section serves to develop your model. All symbols should be defined/identified. Any approximations you make in going from your physical model to the mathematical model should be noted. Lengthy derivations can be included here or placed in an appendix. Results (and proofs, where appropriate) can be included in this section or can stand alone in their own section.

Numerical Work (if appropriate) or Examples: This section describes your algorithms and/or numerical work and/or examples. A descriptive summary of your code and results can be included here. You can put any (well-documented!) code that you write in the appendix. Graphs and/or tables with data you used or computed should be in this section.

Discussion/Conclusions: What did you find? Is it what you had expected? How can you use your results? What do they tell you about your original question? Is there any pertinent future work that should be done, *i.e.* how could/would you continue to further your understanding of this topic?

References All books, articles, and websites used in the preparation of your paper should be documented in this section. Note that if you do not properly document your references and attribute the results that you used to the proper sources, then your work is plagiarism. **You must have at least 3 non-internet/non-web references, *i.e.* actual books or journal articles that you referred to for your project.**

Additional items to keep in mind:

- You must work in groups of at least 2 and no more than 3. Each group needs to turn in only one copy of the project.
- Cover pages are not needed, just a title, date, the name of each of your group members (in alphabetical order) at the top of the page. You can also print 2-sided if you wish.
- Give complete definitions of all terms and symbols used.
- Numerical development and/or examples, explanation and discussion is important.
- Writing style, clarity and completeness of explanations is also important.
- Figures, graphs, and tables should have labels, captions and legends, as appropriate. You should discuss each figure in the text, as in "We see from Figure 3 that ..." If you do not discuss it in the text, it should not be included in the report!
- Reference facts that you state in your paper. Include all references at the end of the paper.
- In general, code should be in an appendix and graphs and figures should be in the text where they are first discussed.

The project is worth 100 points. Each of the following elements will have the following value:

- The 2-page project proposal, due on March 12^{th}, is worth 10 points.
- The project rough draft, due on April 9^{th}, is worth 30 points.
- The final project, due on April 26^{th}, is worth 60 points.

Remember: The final project is due on April 26^{th}. This is the Monday of the last week of class.