Math 194: Methods of Linear Algebra
Application Projects

Overview

The linear algebra ideas and techniques you are studying this semester have applications in a variety of fields. Learning about the ways in which mathematical ideas are applied to problems from other disciplines is one of the goals of this course. To that end, you will be required to complete an application project during the semester. The project will take the form of a proposal (due Tuesday, November 12th), a poster presentation during the last class session (Thursday, December 5th), and a properly formatted and referenced paper about five pages long (due Friday, December 6th).

The application project should demonstrate your understanding of a particular problem from the engineering sciences or other discipline, the mathematical concepts and techniques that can be used to solve the problem, and the ways in which mathematical modes of thought are brought to bear on the problem. The project should be an extension of mathematical ideas or applications seen in this course.

Please note that you **must** work with a partner on each part of your project. You are responsible for sharing the workload with your partner fairly. I have three reasons for this policy: (1) the quality of your work will likely be greater than it be if you worked alone, (2) developing collaboration skills is a valuable learning goal for this project, and (3) having half as many projects to grade and on which to provide feedback makes it more feasible for me to implement this very important assignment in this course.

Part One – Proposal

For your proposal, due Tuesday, November 12th, your team will describe a particular problem from the engineering sciences or other discipline that can be addressed through the use of the one or more of the linear algebra techniques was have studied this semester. Your team should **not** attempt to use these techniques to actually solve the problem you describe in this part of the project. However, you should pose one or more interesting questions relevant to your problem and make the case that these techniques could help someone answer those questions. You are welcome to explore an interesting problem that has already been solved (see below for suggestions where to look for one of these) or pose an original problem that has not yet been solved. You should include any data relevant to the problem you choose—or instructions for how someone could obtain such data.

This first part of your project should take the form of a 400-to-600 word post on the course blog. I'll upgrade one member of each team to "contributor" status on the blog so that s/he can post your work. Although I'll be the one grading your project proposal, it will be available on the blog for everyone to read, so write accordingly. You may assume that your audience is familiar with the material we have covered together as a class this semester. (If you'd rather not use your real name on our public course blog, that's fine—just pick a pseudonym and let me know what it is.)

You will be graded on the extent to which the problem you describe is a reasonable application of the linear algebra techniques covered in this course, as well as on the clarity of your writing. Grammar and presentation will be factored into your grade to a lesser extent.

This first part of your project will count for 20% of your overall project grade.

I will provide you with feedback on your proposal, discussing the feasibility of your proposed project and suggesting ideas for enhancing your project.

PART TWO – PAPER

For your paper, due Friday, December 6th, your team will actually use the linear algebra techniques studied in this course to address the problem posed in your proposal. In your paper, your team should clearly explain

- the context of the problem you have chosen,
- the mathematical model used to solve the problem (along with any assumptions made about the problem), and
- the analysis of the mathematics used to answer interesting questions about the problem.

Most papers should be about five pages (typed, double-spaced), but the amount and type of mathematical notation may result in some longer papers. Several software packages enable one to include mathematical notation in a document, including Microsoft Word (through its Equation Editor tool), Mathematica, and LaTeX. Please ask me if you need help using one of these software packages.

The paper should be written as if to a fellow student in Math 194. Thus you may assume that your audience is familiar with the material we have covered together as a class this semester. Your explanations should be clear enough that a fellow student would be able to follow them. In particular, you should not treat your methods as a "black box;" you should provide enough explanation for your methods that a fellow student would have a good understanding of why it works the way it does.

You will be graded not only on the depth of your understanding of the application you choose, but also on the clarity of your explanations. Grammar and presentation will be factored into your grade to a lesser extent. The second part of your project will count for 70% of your overall project grade.

Your team's paper should be submitted via email by noon on Friday, December 6th. This gives you an extra day after the poster session if you need it, although you're welcome to submit your paper on the last day of class. Please also submit via email any Matlab, Mathematica, or other software files you use in your project. As I am reading and grading your paper, I might want to verify your calculations or otherwise experiment with your data.

Here are two other tips: (1) Sweeping statements (like "Since the arrival of mankind…") in opening paragraphs don't read well. It's better to be specific and concrete and to make statements you can support with sources. (2) Some of you may find it easier to construct matrices in Excel, then cut-and-paste them into Matlab or Mathematica for analysis.

PART THREE – POSTER

During the final day of class (in a room to be announced), we'll have a poster session during which you will share your projects with your classmates. Your poster should be a science fair style poster, probably on a tri-fold presentation board. Your poster should use text and graphics to convey very quickly the essential ideas in your project to your classmates.

During the first half of this poster session, one person from each team will stand by his or her poster while the other person wanders from poster to poster. The person standing by his or her poster should be prepared to explain his or her project to students who visit the poster. During the last half of the poster session, teammates will switch roles so that everyone gets to see all the posters.

When you are browsing the posters, you will be given the opportunity to vote on your classmates' projects in the categories of Most Interesting Application, Most Sophisticated Mathematics, and Most Attractive Poster. Winners will be announced at the end of the poster session. Students with winning projects will receive bonus points to their project grades.

I won't evaluate your posters, since this part of the project is primarily intended as a way for you to share your work with your fellow students. However, the poster will contribute 10% of your project grade on a completed / not completed basis.

CITING YOUR SOURCES

You must cite your sources appropriately, and a list of references must appear at the end of your paper, formatted appropriately. It does not matter which formatting style you use (APA, MLA, etc.), but you should be consistent in your formatting. Be sure to format your citations (footnotes, endnotes, etc.) correctly according to the formatting style you choose. (Just including a footnote with a link to a Web page doesn't cut it.) For guidelines on documenting sources, avoiding plagiarism, and other relevant writing topics, please see the Vanderbilt Writing Studio's resources for students[1].

Make clear what references you use and how you use them. Did most of your paper come from a single journal article? If so, then there is no need to cite it in every paragraph, but you should explain your use of the article clearly in your paper and cite direct quotations from the article. Did your paper come from a variety of sources? Make it clear what ideas (facts, computations, analysis, etc.) came from which sources through proper citations. That is the spirit of not plagiarizing—making it clear where you obtained your ideas.

[1] http://vanderbilt.edu/writing/resources/

Whatever else you do, do not plagiarize! Cite your sources, and consult Vanderbilt Writing Studio's list of resources for students for more information on plagiarism. If your life is falling apart and you are tempted to plagiarize to save time or get a good grade, please see me instead. I would rather grant you an extension than send you before the Honor Council for plagiarism—but I will send you to the Honor Council if it comes to that.

Also, pay attention to the quality of any sources you reference. Determine if you have a reputable source or not. Wikipedia is not an acceptable source—not because its entries are user-generated, but because no encyclopedia is an acceptable source. You're welcome to use Wikipedia as a starting point for your research, however. Most statements in Wikipedia are referenced at the bottom of the Web page. Follow these references for sources to use instead of Wikipedia itself.

TOPIC IDEAS

One place to find topics is our own linear algebra textbook—or other **linear algebra textbooks** you can find in the Science & Engineering Library around call number QA 184. You can also find topics in **scholarly journal articles** in engineering or other journals, many of which are available online through the Vanderbilt library. You are also welcome to **collect your own data for analysis** using techniques from linear algebra. I'm glad to talk to you about the feasibility of any idea you have for gathering your own data.

We've looked at a number of linear algebra applications in this course. Here are a few you might choose to explore more deeply in your projects:

1. *Leontief Economic Models* – Describe one of the Leontief input-output models (closed or open) and its history. Use the model to analyze a relatively simple economy,

perhaps one involving actual (if simplified) data. One year, a student used approximate real-world data to analyze the economy of Saskatchewan. Another student used one of these models to look at pollution management issues.

2. *Markov Chains* – Model a board game (e.g. RISK, Chutes and Ladders), sport (e.g. tennis, baseball, jai alai), or real-world situation using a Markov chain, then determine optimal strategies through an analysis of the model. Or use the basic ideas behind Google's PageRank algorithm for ranking the popularity of Web pages to rank some other set of connected items. Or figure out ways to use Markov chains to generate random, but sensible text—like @BabbageBot[2], but better.

3. *Discrete Dynamical Systems* – Analyze a population, perhaps using actual birth, survival, and death rates, using the eigenvalue approach to dynamical systems. One year, a student used simplified real-world data to analyze Zimbabwe's population growth.

4. *Computer Graphics* – Expand on our class discussion of the use of linear transformation in computer graphics. Use linear transformations to manipulate an "object" in three-dimensional space.

5. *Cryptography* – Expand on our class discussion of Hill ciphers or other ciphers that use ideas from linear algebra. Perhaps find a historical use of such ciphers to describe in your paper.

[2] http://twitter.com/babbagebot