Math 334 Earthquakes and Buildings
Group Project Due 2:00 pm Monday, April 23

Earthquakes can cause serious damage to buildings, particularly if they create large vibrations throughout the building structure. Multistory buildings can be especially susceptible to this, so in this project we will create mathematical models allowing us to study the effects of earthquakes on a multistory building design, so that you can propose methods to minimize damage.

Our design calls for a four-story building. The ground floor is integrated with the foundation and thus in an earthquake it will move with the moving earth. Each floor above this, and the roof above the top floor, has a proposed mass of 20 metric tons. The steel structure connecting the floors will produce a restoring force that we can model with a spring constant of 120,000 N/m. We will assume that the important motions of the earthquake are purely horizontal in one dimension, and that the motions of the floors are parallel to this. We will let $x_1(t)$ represent the position of the first floor, which is attached the ground, and thus moves passively with the earthquake. $x_2(t)$ represents the position of the second floor, $x_3(t)$ represent the position of the third floor, $x_4(t)$ represents the position of the fourth floor, and $x_5(t)$ represents the position of the roof. In all cases $x_i(t) = 0$ is the equilibrium position. We will assume that an earthquake can be modeled with the function $x_1(t) = A\sin(\omega t)$ for some amplitude *A* and some angular frequency ω. Then you will need to determine the motions of the floors above, $x_2(t)$, $x_3(t)$, $x_4(t)$, and $x_5(t)$, that will result. If we consider only the restoring forces of the steel structure connecting the floors, then we can write $F = ma$ for each floor and the motion of the roof will be modeled by the equation $m_5 \frac{d^2x_5}{dt^2} = -k(x_5 - x_4)$ because it only feels a restoring force from the floor below. Each of the other floors feels two restoring forces, one from the floor below, and one from the floor above, thus $m_4 \frac{d^2x_4}{dt^2} = -k(x_4 - x_3) - k(x_4 - x_5)$, $m_3 \frac{d^2x_3}{dt^2} = -k(x_3 - x_2) - k(x_3 - x_4)$, and $m_2 \frac{d^2x_2}{dt^2} = -k(x_2 - x_1) - k(x_2 - x_3)$.

How will this building design respond to earthquakes with different frequencies? Are there certain frequencies that would be particularly damaging to this building as designed? Is there anything that we can do to minimize the damage that earthquakes could cause to this building? Perform a mathematical analysis of any methods that you can propose to make this building more earthquake resistant. Please investigate this system using both linear algebra and numerical methods (Euler's method).

For this project you will work in groups of 2 or 3, you will study this system as thoroughly as possible, you will write a formal paper merging together text, equations, and figures in order to explain your work, and you will make an illustrated presentation to the class.

Important Dates:

Papers are due on Monday, April 23, 2012 at 2:00pm. Presentations will be on Monday, April 23, and Wednesday, April 25.

MA 334 – Group Project
Guidelines and Important Dates

Important Dates:
April 23 – Written report due at 2pm on the shares drive S:\kcline\MA 334\Projects 2012
April 23 & 24 – Oral Presentations (between 5 and 10 minutes each)

Guidelines:
You must work in groups of 2 or 3. You should turn in one written report for your group, and your oral presentation will be done as a group. Every student should have some part in the oral presentation, and the presentation should be done with Power Point.

Your written report should be done in Microsoft Word, using equation editor, or some other comparable word processor with mathematics capabilities. It must include headings separating out the **introduction**, a **conclusion**, and **references**, as well as any other sections you think make sense. You should use the introduction to briefly summarize the problem in your own words and set the stage for your paper. In the conclusion you should summarize your results and tie things together.

One other requirement for the written report is a **one-page summary** which will be the first page of your report. This should be a brief overview of your entire project, including a very short problem description (shorter than in the introduction), the main methodologies used, and a brief statement of the main results you achieved. Final results must be included! Think of this as possibly the only part of your report that a senior manager might read. It needs to clearly and succinctly summarize what you have done.

Contributions, References, Plagiarism, & Integrity:
Each team must submit a page, signed by both team members, either stating that both team members contributed equally to the project or offering an explanation and relative efforts if contributions were not equal. All papers must contain a "References" section in the APA style that lists our textbook: Our text was the original source of most of the techniques that you will use in this project. If you get any other help on this project from other books, web sites, other student work/papers, or even if you talk to other classmates outside of your team, you need to include these in your reference section, acknowledging that not everything in your paper was your own original idea. You must give in text citations to any particular ideas from any of the sources that you reference. It is very important that there is no file sharing, of Word documents, Excel files, Matlab commands, or any other electronic files of any kind: That is considered cheating. You and your team must type in everything yourselves, into Word, into Matlab, into Excel, and any other tools that you may use. If you include a reference, you may talk to your classmates outside of your team about the general ideas of the project, but you may not copy the specifics: We expect all teams to do their own explorations.

Writing
Write in the first person, and use the active voice whenever reasonable. For example, rather than, "It was discovered that…", write "We discovered…".

Present your equations and figures clearly. Equations should be formatted in equation editor rather than simply typed out as text. Clearly define all variables. Equations, figures, tables and numbers should be included in the body of the paper: Don't hide them in an appendix. Please label all tables and figures, and be sure to label the axes of your figures. Each figure must be discussed individually in the text. Explain exactly what we are supposed to learn from each figure. You should explain things well enough that we

can read through the paper without looking at any of the figures and still understand your results. If a figure or table isn't explained in the text, then it should not be included in the paper.

Spelling and grammar count – proofread carefully!

The introduction and conclusion should *not* be judgments about the problem – refrain from saying, for example, "In conclusion, this was a worthwhile project. I learned a lot." Your introduction should set the stage for your paper – sort of an overview of the problem. Your conclusion should tie together the paper and highlight the major results.

Some Presentation Suggestions

Have fun making your Power Point presentation, but beware of getting so fancy that it detracts from your content. Very plain slides with no moving words are perfectly acceptable. Make sure to use a very light background color and to use black for your text and equations. There are lots of color combinations that work on the computer screen, but are almost impossible to read when projected up for the whole class.

You will probably not have time during your presentation to discuss every aspect of your problem. Do be sure, though, that you appropriately introduce your problem.

Make sure your presentation is saved in two different ways – on your X drive and on something else (a disk or a flash drive). You are responsible for having your presentation in working order at the time you are scheduled to present.

MA 334 – Grading Outline for Projects

PROJECT REQUIREMENT	SCORE	POSSIBLE POINTS
Summary – originality, persuasiveness, clarity of vision		10
Problem Description – problem is clearly stated; written for someone who doesn't know what project is		10
Linear Algebra Analysis – Identification of particularly damaging frequencies		20
Euler's Method – Analysis of building response to various frequencies		20
Proposed Methods – to make the building more earthquake resistant, and mathematical analysis of their effects		20
Conclusion & References– the main results are restated and tied together at the end of the paper, all sources are listed and cited within the text		10
Mechanics/Graphs – paper uses correct spelling, grammar, and punctuation; paper flows well from section to section, tables and graphs are labeled and discussed in paper		10
Presentation		20
TOTAL		120

Presentation

Mathematics

6 pts. All mathematics is correct. Proper mathematical notation is used. All unknown terminology is explained. Presentation demonstrates an understanding of the mathematics.

4 pts. The above is mostly done well, but there are occasional minor problems with one or more areas.

2 pts. One of the above is done badly, or there are many minor problems.

Communication

6 pts. Presenters communicate material effectively. Demonstrate enthusiasm, interest, and creativity. All team members contribute to the presentation.

4 pts. The above is mostly done well, but there are occasional minor problems with one or more areas.

2 pts. One of the above is done badly, or there are many minor problems.

Organization

6 pts. The presentation is organized and the method of presentation is well chosen. The problem is clearly described. Ideas are connected to the topic and each other. The timing and pace is appropriate for a 5 to 10 minute talk.

4 pts. The above is mostly done well, but there are occasional minor problems with one or more areas.

2 pts. One of the above is done badly, or there are many minor problems.

2 pts. will be given for attending all talks. (This will be done on an individual, rather than a group, basis.)

Total presentation points: _____ (20 possible)