Important Checkpoint Dates

- **Mon Sep 14:** Potential group members & general area of interest, communicated to me. From this information I will finalize the groups.
- **Mon Oct 5:** Specific topic and initial reference list communicated to me.
- **Wed Nov 11:** Rough draft of paper given to me for feedback. You should consult with me before this, of course, as you work on preparing your rough draft!
- **Fri Dec 4:** Final version of Presentation made available to class on moodle site.
- **Fri Dec 11:** Final version of Paper due (uploaded to moodle for me to grade, not shared with rest of class unless you wish to do so).
- **Fri Dec 11:** Individual Reflection due (each member of group completes their own reflection).

Purpose of Applied Project

Some of you have done "Applied Projects" for me before in calculus. This Applied Project is different from those, in that I am not giving you a specific problem to solve, instead I am asking you to learn about an area of mathematics related to ordinary differential equations that you find interesting. It can be an extension of a topic we have done in class, a topic not related to anything we have done in class but based on ordinary differential equations, or a significant application we have not done in class but using techniques we have studied in class. After your group has determined the general area you wish to work in, you will find resources, refine your topic, write a paper, and create a presentation. I can help with all these tasks, but I want the group to be the driving force behind all decisions.

The Applied Project will allow you to

- practice working on problems that are not explicitly provided to you,
- explore an area of mathematics that is of particular interest to you,
- work in a collaborative environment,
- practice writing a technical paper,
- practice organizing a short presentation of your work.

Your Paper

Your paper should be about 10 pages long (double spaced, 12 point *Times New Roman or Computer Modern* font), and written with proper sectioning, numbered equations, and include an abstract and bibliography. Depending on your topic and diagrams included, the final paper might be 8–12 pages long, but should not be shorter that 8 pages or longer than 12 pages. The paper should be typeset using Word, LaTeX, or *Mathematica*, and converted to a pdf for final submission.

There is a short Word document that serves as a Math Style Template for writing a mathematical paper. It was created for Math 4901 (the math senior seminar), but can be applied to any mathematical paper you are working on. You will use this to structure your paper. It can be downloaded here:
http://facultypages.morris.umn.edu/math/4901mathstyle.doc.

Your Presentation

The presentation will be an electronic format that will be shared with the class in moodle. There are a multitude of tools you can use to do this, here are some I have verified will work (I will post short descriptions of these techniques in moodle, with links to software):

- record a live presentation using a phone or camera (make sure the audio/video quality is great!)
- narrated powerpoint
- screencast

The screencast would be especially useful if you wanted to show some *Mathematica* animations in your presentation.

You should feel free to use other tools, but make sure they work well before you invest a lot of time in them. Some popular alternatives I have not used are voicethread and prezi. I have heard good things about voicethread, so it might be worth checking out. To be honest, I find prezi a bit daft (any highly animated presentation really, not just prezi), but if you want to use it go for it! For the prezi I think you would need a screencast to create the presentation.

The presentation should not include everything in your paper, but enough to convey the important concepts. A presentation should be around 10 minutes in length. The shortness of the presentations will be a challenge, but it is quite common to have only 10 minutes at a scholarly conference to present your findings.

Remember, the presentation is about communicating information to your audience (so think first about who is your audience), not about flashy effects. Keep the following in mind as you prepare your presentation:

- Introduce the topic, and why it is interesting to you.
- Description of problem (with sufficient mathematical detail that can be conveyed to audience in short time).
- Clarity and organization of material (avoid showing anything the audience doesn't have time to follow or understand).
- Enthusiasm doesn't just mean being loud. Are you keeping your audience intellectually engaged?

Most importantly, think about what you want your fellow classmates to take away from your presentation (it probably won't be everything that is in your paper). The audience should understand the broad picture of what you have done, and if they want more detail they can read your paper or you can go out for coffee with them to talk about it. Really, that's the goal–get them interested enough to want to learn more!

Your Individual Reflection

Each person will submit their own Individual Reflection, a one page reflection that contains a summary of what you have learned through completing the Applied Project. Things you should address in your reflection:

- How did the structure of the Applied Project help you learn about your topic?
- What were your specific contributions to the project?
- Do you feel your contributions were significant?
- What strengths did your group have?
- What challenges did you encounter completing the work as a group, or areas you could improve on?
- Did your group work well together?

A Note About Group Work

You must work in groups of two or three people on the applied project. How you divide up the work is up to you, but each member should contribute an equal amount to the overall project, as each group member will receive the same grade, *except for the grade on the individual reflection.*

One way to divide the work is to have a group member who is the coordinator for a certain part of the project. For example, a group of three may choose to have one person in charge of getting references from the library, one person

does the first draft of the paper, and the third person does the first draft of the presentation (determines what tools to use, structure of presentation, or if a video is chosen as presentation media does the actual presentation). The other members of the group will contribute and offer input on these tasks, but the coordinator is ultimately in charge of getting it done. **All group members will contribute equal effort to the scholarly process of creating the information that will go in the paper and presentation.**

Keep in touch with the members of your group throughout the semester, and ensure that progress is being made on your applied project (clarifying the question, finding references, getting a rough draft written, etc.)! **Turning a task over to someone and not getting reports from them on their progress until just prior to one of the checkpoint dates is a recipe for disaster.** Even though you may not be coordinator for a task, you should be seeing progress on it. Also, if you are the coordinator and are having difficulty with something, the first thing to do is talk to the rest of your group about it to see if they can help you. Regular meetings throughout the semester are a requirement to ensure your project stays on track. Your group (in whole or in part) can also come see me when you have questions about your topic.

Possible Topics

Here are some possible topics for your applied project. You can of course choose other topics, just talk with me if you are interested in something not on the list–the list isn't meant to be complete!

- Introduction to boundary value problems
- Introduction to dynamical systems and chaos
- Introduction to partial differential equations (separation of variables)
- Introduction to integral equations (this would be a challenging topic)
- Exponential of a matrix and its relation to linear systems
- Deficient Eigenspaces and their relation to differential equations (good topic if you have had linear algebra)
- Special functions (an examination of another special function besides the Bessel function)
- Another numerical technique besides Taylor's method of order n
- Discrete time dynamical systems
- Proof of the existence and uniqueness theorem (this would be a challenging topic)
- Applications of techniques studied in class to other areas, including:
  - voltage and resistance in circuits
  - predator-prey models
  - pursuit problems (for example, a dog chasing a rabbit)
  - planetary motion (the three body problem)
  - population dynamics
  - epidemiology (SIR models)
  - Hamiltonian systems from physics
  - the Schrödinger equation in quantum mechanics
  - bifurcations and fixed-points
  - modeling using real-world data (typically challenging, since it is hard to find good data!)
  - oscillations in chemical reactions

Grading

The grading rubric is included below.

Name: Title: Grade: /100

	Exemplary **10 – 9 pts**	**Acceptable** **8 – 7 pts**	**Unacceptable** **6 – 0 pts**	**Score**
Individual Reflection / Met Deadlines (10%)	● all components submitted on time ● contributed sufficiently to project ● strong individual reflection	● at most one component submitted late ● contributed sufficiently to project ● individual reflection lacks depth	● multiple components submitted late ● did not contribute sufficiently to project ● individual reflection lacks depth	1 × ___
Use of Disciplinary Language (10%)	● notation and terminology used correctly ● assumptions clearly stated ● quantities defined before use	● a few notation or terminology errors ● assumptions are usually stated ● quantities are defined	● frequent errors in notation or terminology ● inconsistent notation ● assumptions invalid or not stated ● quantities not defined	1 × ___
Depth of Project (40%)	● content builds on Math 2401 topics and challenges students ● examples are well chosen ● math used is correct	● content challenges students ● topic is elementary but has sophisticated examples ● any math errors are not serious	● content does not challenge students ● examples are trivial or missing ● math errors are significant	4 × ___
Paper **Mathematical Formatting / Quality of Writing (20%)**	● follows Math Style Template ● formulae correctly formatted ● derivations made easier to understand by appropriate explanation ● grammar mechanics and usage are correct and enhance understanding ● logically ordered with helpful transitions made to improve understanding	● a few formulae not correctly formatted ● some instances worthy of explanation omitted ● grammar mechanics and usage occasionally hinder understanding ● paper occasionally missing transition between sections, but still understandable	● little attention paid to line-breaks ● little attention paid to formatting mathematical symbols ● grammar mechanics and usage often hinder understanding ● little help is given to the reader to understand the argument ● little thought given to the ordering or transition between topics in the paper	2 × ___
Presentation **Mathematical Formatting / Effective Use of Presentation Tools (20%)**	● formulae correctly formatted ● effective use of presentation tools to enhance understanding ● presentation logically ordered with helpful transitions made to improve understanding	● a few formulae not correctly formatted ● some instances worthy of explanation omitted ● use of presentation tools occasionally hinder understanding ● presentation occasionally missing transition between sections, but still understandable	● little attention paid to formatting mathematical symbols ● use of presentation tools often hinder understanding ● little help is given to the reader to understand the argument ● little thought given to the ordering or transition between topics in the presentation	2 × ___