PHYS-3202 Class Project Instructions

You will carry out a project involving both analytical and numerical calculations and write up your results in an article style. This project will address some topic in classical mechanics that we have not had time to discuss in detail in class. Some suggested topics are listed below.

At a minimum, I expect that these projects should require time and effort equivalent to one or two weeks worth of homework assignments, and the written report should be at least 5 pages (including title information, abstract, and bibliography). You are, of course, free to spend as much time and effort as you like, as well as to write a longer paper. Your project must have both an analytical/theoretical and a numerical component. You may use any software you are comfortable with (for example, Maple, python, C++, etc) for the numerical work.

You may work in groups, as discussed below. You must have me approve the topic of your project in person by **8 Nov 2019**, and the reports are due at **10:59PM on 4 Dec 2019** either emailed to me as a PDF or to the homework drop outside 2L26 as a hardcopy. **This project is worth 15% of your final course grade.**

Please come discuss with me or send me an email if you have any questions.

Group Work

You are allowed and encouraged to work in groups of up to three students. In this case, the total effort (not necessarily the total length of the report) should increase accordingly; that is, the project from a group of three students should represent three times as much effort as an individual student's project. Furthermore, in addition to a single written report from the group, I will require a statement from each student in the group regarding the contributions of each group member to the project. In other words, students A, B, and C working in a group should each submit a statement indicating that student A did $X\%$ of the work on calculation Y and wrote all of the corresponding section of the paper, etc.

Report Format and Outline

One goal of this project is to give you experience in writing a physics article in the style expected for a research journal since writing technical reports is a requirement of many jobs, not just in academia.

The article itself should be written using either the LaTeX or MS Word template available on the course web page. (LaTeX format is strongly preferred.) In either case, the report should be delivered either as a single PDF file or a hardcopy. If you opt to use the MS Word template, you **must** use an equation editor to display your math. You also **must** have a bibliography with references cited by number in the text. The bibliography should be ordered in the order references are cited (see the templates).

Following the template, the report will have the five sections described here.

- **Title Material**: The beginning of the article should give a title, a list of authors, and a short abstract giving a brief description of the project and summary of the results in a few sentences.

- **Introduction**: Describe the problem you are studying and why it is important. Review and cite any references you have read about the problem *in your own words.* Indicate what the results will be.

- **Methods**: Describe the equations that you will need to solve and the methods you will use to solve them. These should involve both your analytical approach or approximation methods (such as approximating a potential near its minimum as a harmonic oscillator) and how you set up the problem for solution on a computer. It is likely that most of your typeset formulae will appear in this section.
- **Results**: Present both your analytic and numeric/computational results. This will include formulae for analytic solutions and some representation of numerical solutions. Plots are recommended.
- **Discussion**: Discuss the conclusions of your project in the context of the problem you wanted to solve and related questions in physics. Make sure you relate back what you discussed in the introduction.

Evaluation

Marks for the class project will be based on the following distribution:

- **Topic/Plans**: 10%
  You must have your topic approved at an in person meeting with me by **8 Nov 2019**. This includes identifying any group working together. You will automatically receive these marks if your topic is approved on time.
- **Effort**: 20%
  Does the project show evidence of sufficient effort (ie, equivalent to 2 or 3 homework assignments per student in the group)?
- **Title Material and Format**: 10%
  Do the title and abstract accurately describe the problem and results? Is the format of the article including bibliography correct?
- **Introduction**: 10%
  Is the problem well described and put into context? Are references to the problem and related problems cited in the text?
- **Methods**: 20%
  Is there sufficient mathematical analysis to solve the problem? Is it explained clearly? Are the techniques you use, including computational ones, understandable? Is the mathematics formatted correctly?
- **Results**: 20%
  Are results explained thoroughly? If plots are appropriate, are they labeled completely, captioned, and described in the main text? Have you considered enough angles of the problem? Do you have both analytical and computational results?
- **Discussion**: 10%
  Do you summarize your results accurately and explain how the results relate to the question you wanted to address? Do you explain how it fits in the broader context in physics?

Typically, if the work is divided reasonably equitably, all students in a group will receive the same marks. However, if student responses indicate that the workload was distributed in a highly uneven manner, I reserve the right to adjust grades as appropriate.

Suggested Topics
You may find the following suggestions helpful when choosing a topic for your project.

- The University Physics Competition has a list of past problems, many of which involve classical mechanics related to the use of differential equations as we have studied in this course. You may choose one and consult with me how to extend it for this project.

- Air resistance has other effects on moving objects. You could give a derivation and numerical simulation of the origin of lift on an airplane wing or other flying object. Or you could study the Magnus force, which is a force due to air resistance on spinning objects, and its effects in sports for example.

- We gave only a cursory overview of orbits. You could examine one of several topics: stability of circular and elliptic orbits, how the planets affect each others' orbits (including how Neptune was discovered), or precession of Mercury's orbit due to general relativity. You may find some discussion in the supplementary textbooks, but you will need to consult with me about how to go beyond them.

- We briefly mentioned Hohmann transfers as fuel-efficient orbits on a homework. Work out the appropriate orbits and fuel needs for a variety of space probe orbits optimized to different criteria (for example, speed). Examing how gravity assists work. Perhaps study a real-life space probe example.

- KB chapter 13 and some of the appendices explain mathematical tools for studying nonlinear differential equations of the form that arise sometimes in mechanics. Select a set of some of the more difficult homework problems or pick some physical example as an application. See if there are indications of chaotic behavior. Some of the appendices or chapters in supplementary textbooks may be useful. KB chapter 14 also has relevant information, but you might need material that won't be discussed until PHYS-3203 for it.

If a topic is something that will come up in PHYS-3203, I may veto it. Remember that I must approve your topic choice at an in-person meeting by Nov 8.