Classical Mechanics (PHYS 350) Course Syllabus

Fall 2013 v6.5

1. Introduction to Phys 350:

The content of this classical mechanics course is both purely practical and somewhat esoteric. In its midst we find explanations of the Tippe-Top toy (see web page for picture) and Rattle-back (see web page for movie), methods to analyze flying disks, and ways to formulate physics that philosophers ponder. Full of intricate (and elegant 19^{th} century) mathematics, the subject also frames the very questions that physicists ask, such as "What is the Lagrangian for your theory?" and "Is the model stable to linear perturbations?" In fact, there are few subjects we could choose to study which are as theoretically satisfying and full of practical application.

At the undergraduate level, the subject has evolved toward the theoretical. It seems that teachers and authors have struggled to find practical applications. Many of the "applications" are created to highlight theoretical methods. This is fine, but in my view problems ought to fall into three categories in roughly equal proportions. There ought to be exercises to learn new techniques, problems which point out surprising aspects of the subject, and applications to our everyday world. In this course I try my best to avoid losing sight of the latter type. In addition, to emphasize the practical and amusing we will spend a week on the analysis of a number of famous toys. Naturally, this occurs just before winter break.

As for subject matter the course is a tripartite mix of review, Hamiltonian (imagine, our very own method in mechanics! Well, not quite...[1]) and Lagrangian dynamics, and applications. The core is the new formulation of dynamics and the substantial range of new techniques in the applications.

Our text is Morin, which is new, pleasantly conversational, much cheaper than many textbooks, and full of worked examples. However, over the years I have developed my favorite presentation of the subject and so class will differ in a number of small ways from the text.

We will also draw from a number of other texts including (ranked in order of increasing difficulty):

- Kleppner and Kolenkow – **An Introduction to Mechanics** An introductory text at a high level, it is a very nice stepping stone between Giancoli or Haliday and Resnick and T & M. (QA805 K62 1973)
- Baierlein, **Newtonian Dynamics** – A concise, physical treatment (QA845 .B33 1983)
- Taylor (the one who wrote the error analysis book) **Classical Mechanics** (QC125.2.T39 2005)
- Fowles, **Analytical Mechanics** – A good complement to T & M (QA807 F65 1986)
- Thornton and Marion, Classical Dynamics of Particles and Systems – The standard Hamilton text prior to Morin's (QA845 .M38 1995)
- Cvitanović **Universality in Chaos** – A collection of papers on non-linear dynamics (QC20.5.U54 1984)
- Symon, **Mechanics** – A great text at a higher level (QC125 S98 1960)
- Hand and Finch, **Analytical Mechanics** – A beautiful advanced junior-level presentation. Great on Lagrangian mechanics (QA805 H26 1998)
- Goldstein, **Classical Mechanics** – The classic graduate level text, worth dipping into on occasion (QA805 G6 1980)

No doubt you have noticed the scheduled extended class time. Over the years Brian and I have decided to augment the traditional "lecture & problem set"-form of mechanics. Instead of three lectures a week, we will have a mix of "lab", lecture, recitation, and presentations.

[1] For aspiring historians: Is there any relation between Alexander Hamilton and William Rowan Hamilton?

2. Presentations:

The typical "Friday class" consists of a series of solutions and 10-15 minute presentations punctuated by discussion. We all contribute but I emphasize the complete reversal of roles. You take an active role in teaching yourselves. It is your class! There is but one rule: Except for your final toy presentation when you may use it if you'd like, there will be no PowerPoint presentations.

Here are a few suggestions to help you along. Slogans lead the more detailed descriptions.

(1) *Start early. Work slowly and carefully.* Nothing will help you better than to start preparing for your presentation early. As good as they are, these chapters are not short stories; it would be unpleasant to read the entire chapter in one sitting. Further, read with a scratch pad and writing utensil; work through the presentation of the text. Schedule in plenty of time.

(2) *Work all the problems.* Dance is not learned (only) by watching video; physics is not learned from (only) reading. To learn the subject one must try out the stuff by talking and writing about it and working through problems. For many of us this process has two purposes. One is to gain mathematical fluency. The other is to find the physics in the mathematics.

(3) *Minimize frustration!'* One of the aspects of the seminar experience that took me the longest to learn was the utility of asking a question. If you encounter difficulty, carefully formulate a question (often the question answers itself in this process!), then ask someone. If this person is madly preparing a midterm or a French buttercream or does not know the answer, try someone else. In particular do not hesitate to ask me (Science G052, x4919, smajor). If all else fails, go on to other problems and return to the question later.

(4) *Write clean and clear solutions* When writing solutions keep in mind that there is also a large difference in sketching a solution on your napkin at dinner and writing up the solution so that someone can read it (and that may include you!) As with much writing, keep your audience in mind. Keep your classmates in mind but also try thinking of yourself in 3 months. The logical argument of your solution should be clear on a first read.

(5) *For presentations: Be clear. To impress, exhibit novelty.* Much of what is true for solutions also applies to presentations. Clearly state the issue or problem, outline the tools needed, and proceed providing information when needed. Feel free to skip algebraic steps once you have cleared it with the class. Show us (including me) something we don't already know, e.g. a new numerical solution or a experimental manifestation of a problem.

(6) *Preserve class notes* Think of this as writing up notes from which you can relearn the subject.

(7) *Be clear about what you understand and what you don't* It is never too early (or too late) to start being clear about what you understand and what you do not. There is a vast, amorphous plain between familiarity and understanding. Question your own understanding by trying it out on new situations. If your knowledge is not what is required, find the difference and learn from it.

(8) *Make a formula sheet* If you haven't already started, start keeping a sheet of paper with useful formulae so you can quickly answer questions such as, what is the spherical coordinate volume element?

3. Text:

Morin, **Introduction to Classical Mechanics**

4. Colloquium:

On a few Mondays (and an odd Thursday) during the semester we will have speakers from other colleges and universities come a speak on their research. Please make every effort to attend these; they give you an idea about the sort of research that is done and they are part of your physics education.

5. Course info:

All materials will be available online. You can find them through the Courses tab on my homepage http://academics.hamilton.edu/physics/smajor/index.html. The latest versions will be labeled by a version number in the top right of the first page.

6. Grades:

There are 4 parts to the grade:

(1) Problem sets (40 %): Weekly-ish assignments will be posted and distributed a week prior to the due date. I encourage you to work together you but *mus*t write up your *own* solutions. If you received a significant idea from someone else or another source, cite them completely. I highly recommend that you grapple with a problem before you look for help from the book solutions, me, your classmates, other textbooks, or online. But in the course of the semester you will should consult all these resorces. Your presentations will be assessed for clarity and novelty.
(2) Class participation (10 %): Presentations, contribution to discussion and toy week projects
(3) Mid-term: (20 %) The exam will be Friday, October 11.
(4) Final (30 %): The take home final will be due on Thursday, 19 December at 5 PM

7. Weekly Schedule

Given how the semester starts, the "week" starts on a Friday. What follows is out of date.

Week	Topic	Reading
30 August	Newtonian Mechanics I: Point particle	Ch 3 (Also read Ch 1 & 2)
6 September	Oscillations and Phase Space	Ch 4
13 September	Newtonian Mechanics II: Conservation, Rockets & Gravitation	Ch 5
20 September	New Tools I: Lagrangian & Hamiltonian Dynamics	Ch 6
27 September	Dynamics problems	Ch 6
4 October	Central Potential Motion	Ch 7
11 October		**Exam**
18 October	*Fall break*	
25 October	Non-linear Oscillations	Supplements
1 November	Systems of Particles	Ch 8
8 November	Systems of Particles continued	Ch 8
15 November	Non-inertial reference frames	Ch 10
22 November	Dynamics of Rigid Bodies	Ch 9
29 November	*Thanksgiving* No classes	
6 December	**Toy Week!** (and review, too)	Projects
19 December	**Final Due** Thursday 5 PM	

Enjoy!

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