Physics 321 Intermediate Mechanics

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Class Meeting: Monday - Wednesday - Friday 2:00 – 2:50
Sherman Hall 015

Course Overview: This course is the undergraduate upper-level classical mechanics course. You should be starting the course with an understanding of basic Newtonian mechanics from your introductory physics class. Also, you have had the three years of calculus, including multivariable, along with differential equations and linear algebra. This course will be using all of these mathematical techniques to expand your understanding of classical mechanics. The list of topics covered in this class include: Newtonian, Lagrangian, and Hamiltonian mechanics, and their application to oscillators, central-force motion, and the dynamics of rigid bodies. I expect you to be able to work with these methods and understand these applications by the end of the semester. Also, several special mathematical techniques that are used by physicists are covered.

We will cover most of the first section of the textbook (through Chapter 11) in this course, and a schedule of the topics covered is found at the end of this document. Material from other sources will be used, and I will direct you to useful websites where appropriate. Note that I have set the dates for the exams on the schedule. Please do not schedule something else for these dates.

This class is a relaxed lecture setting. In other words, although it will be a lecture course, there is ample opportunity for you to ask questions during the lecture. In addition, there are many opportunities for me to ask you questions during the lecture. We will examine some of the homework problems in detail during class, and you will be asked to lead the discussion in these instances.

Pre-requisite: Physics 224, Math 221, Math 225

Textbook: Classical Mechanics by Taylor
Other good books on this subject (that are in the Physics Library):
Analytical Mechanics by Fowles and Cassidy
Classical Dynamics of Particles and Systems by Thornton and Marion
Mechanics by Symon
Shaum's Outline on Lagrangian Dynamics

Grading: There will be two exams during the semester each of these will be worth 20% of your final grade. The final exam will be comprehensive and worth 30% of your final grade. As with all physics courses, homework assignments are an integral part of learning the material, and will be worth 30% of your grade for this class.

Homework: This is one of the most important aspects of this class. Although you will learn a lot from my enlightening lectures and from thorough reading of the textbook, the only way to learn this material is by working through the important derivations and applying the material to problems. At times the homework will be challenging; remember that it is the only time I can ensure that you examine a complicated problem, as there is not enough time for this during exams.

You are now true physics majors and I expect a bit more from you than other instructors may have expected in the past. In many instances the problems will not have multiple sections that guide you through the solution. Also, I expect there to be a bit of explanation (you know those things called words and diagrams) within your homework solutions. If you look in any technical paper, you find this is true, and this course is where you begin to practice that skill. *A point that I want to emphasis is the need to <u>reference any assistance you get with a problem</u>. In particular, if you come across the solution or part of the solution in another book, and you use that to formulate your own solution, please reference it. If you are working together with another student, please not that on your paper. You will not be penalized for learning how to do something from another source; however, you will be penalized for using another source without noting it.* Another important issue I want to address is neatness. The solutions must be reasonably clean, neat, and complete. Please begin each problem on a new page. One of the best ways to make doing your homework very useful is to work out the solution to the problems, and then copy them over neatly to submit them. This gives you a review of the material right after you have worked on it, one of the methods for learning material that has proven to be effective.

Also, I imagine that you will get together on a regular basis in groups. This is a good tool if used properly and a disaster if used incorrectly. I assume that you will spend 10 hours per week studying on your own for this class. Once you have done your own studying and worked out the problems, it is good to discuss the ideas with others. Please do not use it without working on the problems on your own. If you cannot show a solution in class, you will not receive credit for it in the homework.

Schedule:

Math Review	Jan 31 : Feb 2
Forces and Momentum (1.1-3.5)	Feb 4 : Feb 14
Energy (4.1-4.8)	Feb 16 : Feb 23
Linear Oscillators & Green's Functions (5.1-5.9)	Feb 25 : Mar 4
First Exam	March 7
Lagrangian Mechanics (6.1-7.6)	Mar 9: Mar 18
Spring Break	Mar 21 : Mar 25
Coupled Oscillators (11.1-11.7)	Mar 28 : Apr 1
Central Forces (8.1-8.7, 14.1-14.6)	Apr 4 : Apr 13
Second Exam	April 15
Non-Inertial Reference Frames (9.1-9.8)	Apr 18 : Apr 27
Rigid Body Motion (10.1-10.10)	Apr 29 : May 9
Hamiltonian Mechanics (13.1-13.6)	May 11 : May 16
Final Exam	

Office Hours: I am normally available for students, whenever I can be found. However, to ensure that my classes have an adequate opportunity to see me, my office hours for this class are Monday, Wednesday, and Friday 3-4 (right after the lectures). I will be in my office during these hours. Please take advantage of these hours if you have any problems with the material. This includes both specific issues with homework problems, and general difficulty with concepts.

Academic Integrity: I feel obligated to ensure that students know the repercussions of cheating. If you are found cheating, you will receive a zero for that work and be reported to the Academic Conduct Committee. The university has a website that addresses the concept of academic integrity: https://academicconduct.umbc.edu/

Motivation:

Classical Mechanics is a fascinating subject that lies close to the very heart of physics. With it, we can explain the apparently bizarre motion of precessing gyroscopes, land probes on asteroids with pinpoint precision, and even predict local details of solar eclipses hundreds of years before they occur. In addition, the physics and the mathematics that underpins the subject is pertinent to other areas of physics, particularly quantum mechanics. Everybody deals with classical mechanics on a daily basis, even when just driving a car home. At the fairground, we subject ourselves to pleasurable gravity-defying thrills. We can all relate to the subject, which is one of the reasons it is so fascinating.

Like Latin, Classical Mechanics is a mature time-honored subject. This means that it has been part of the university physics curriculum for a long time, but it is no longer a hot subject for research. Some developments are still being made in the mathematical theory (such as geometric algebra), in chaos theory, and in improving the orbital elements of the solar system. However, it is believed that all of the fundamental physical laws relating to the motion of macroscopic bodies have been discovered and are well understood. It could be said that the purpose of this course is to make sure that the subject is well understood by you too!

Since Classical Mechanics is no longer a mainstream research area, the question arises "Why should students study Classical Mechanics?" I likened Classical Mechanics to Latin, again the dead language that few people use any more. If this analogy is true, then it may seem that the study of Classical Mechanics is a waste of time to the physicist. There are very few employers seeking experts in the theory of coupled pendulums (amusement park equipment vendors are a possible exception). The reason that Classical Mechanics is still an important subject is simple, and becomes clear if we continue the analogy to language studies. Any serious scholar of Indo-European languages needs to know Latin (and Greek, and many other languages and dialects) in order to understand the origins and structure of a language such as English. Even though that scholar does not need to converse in Latin on a daily basis, a strong understanding of Latin is essential, or that scholar will find it difficult to maintain a thriving research program. The analogy holds in physics. If you are taking this course, then you are a serious physics scholar. A serious physicist who wishes to do research needs to understand the field of mechanics at a deep level (as well as other areas such as quantum mechanics, electricity and magnetism, and relativity, etc) in order to understand the connections with other branches of physics, particularly quantum mechanics. In addition, just as Latin grammar provides the linguistics scholar with a framework for understanding the structure of language, the advanced mathematical tools and physical insights learned in Classical Mechanics are invaluable to the physics scholar for many areas of physics.

Another other question that arises during this course is,"why do we need to work through all of these problems by hand, since program tools, such as *Mathematica* can solve much of the mathematics for us digitally?" A reason is that there are certain universal statements found through solving a general problem analytically, such as the instability of rotation around the intermediate moment axis for an asymmetric rigid body. One could spend many hours examining various objects using a numerical software package and not recognize this universal fact. Another reason for doing these analytically is to recognize the amazing amount of information contained in the intermediate stages of the solution. Without examining the central-force problem in detail, one might miss the fact that paths through such a field must be two-dimensional only. Finally, these problems give a chance to exercise knowledge in mathematical physics in a context where the solutions are easily understood. This enables us to have confidence when we use these techniques in less intuitive problems, such as statistical mechanics or electrodynamics.