PHYS 221: Classical Mechanics
MWF 1:00 – 1:52 (Olin 254)
Lab either M 2–5 pm or Tu 1–4 pm (Olin 274)
Fall 2016

Instructor: (*Course & Monday lab*)	Brian Utter brian.utter@bucknell.edu Olin 166A, 570-577-3767	*Tuesday lab instructor*:	Deepak Iyer d.iyer@bucknell.edu Olin 251B

Office hours: (tentative)	M 10:00 – 11:00 Tu 11:00 – 12:00 Th 1:00 – 2:00 F 11:00 – 12:00	I am also happy to schedule appointments at other times! Please visit me early with questions, confusions, or concerns, but I have an open door policy and encourage you to stop by at any point.

Texts: [*required*] ***An Introduction to Mechanics*** by Kleppner and Kolenkow (Cambridge University Press, 2014. ISBN 978-0521198110)

[*optional*] ***Problems and Solutions in Introductory Mechanics*** by Morin (CreateSpace, 2014, ISBN 978-1482086928)

Please also purchase a separate notebook to be used as a dedicated lab notebook.

Overview:

PHYS 221 is for students interested in majoring or minoring in physics, engineers, and scientists who want to learn about mechanics in more depth than provided in PHYS 211-212, as well as anyone else who would like to "get under the hood" and study in-depth the physics behind some fascinating (in my biased opinion) phenomena that most people take for granted. In addition to its inherent interest, the material covered in this course also forms the foundation for other areas of physics and engineering, including nonlinear dynamics, astronomy, quantum mechanics, and various aspects of mechanical engineering.

The course will be taught in an interactive manner, with electronic reading journals on Moodle and in-class problem solving. Lectures will aim to **complement** rather than repeat what is in the texts by focusing on the more challenging aspects as well as putting the material into practice. However, I will present the major points at the beginning of each class. At some points, I might deviate from the approach or material covered in the books. **Everything discussed in class and in labs is fair game for the exams**, whether or not covered in the text readings. It is therefore imperative that you attend class regularly.

The course will begin with a review of fundamental aspects of classical mechanics, emphasizing a methodical (and general) approach for handling dynamics problems. While the basis is the familiar set of Newton's laws, the real world offers plenty of challenges in knowing when and how to apply them. We will continue with an analysis of rotations, orbital motion of objects in central force fields, and the properties of oscillating systems (including those with damping and forcing). You have seen many of these topics before, but we will be studying them at a deeper level, and the problems that you will do will include relatively long, multi-step problems. The treatment will involve significantly more calculus than in PHYS 211, and there will be significant computational work with *Mathematica* as well.

Learning Objectives:

By the end of this course, you should be able to:

—approach complex (and even simple) problems methodically, showing enough work to justify and explain the approach to a reader, and ***never*** taking careless shortcuts (Physics/Astro major learning objectives #1 and 3).

—be proficient in handling problems involving: kinematics, Newton's Laws and dynamics, gravitation and orbital motion, rotations, conservation of energy and momentum, oscillations (including damping and forcing), and coupled oscillations (objective #1).

—be able to use more advanced mathematical techniques in problem-solving, including calculus, limiting behavior and dimensional analysis (objectives #1 and 3).

—be able to analyze experimental data; in particular, determine functional relationships that describe data trends, and use residuals to determine appropriateness of fits to data (objective #2)

—be able to use Mathematica to solve simple problems and to analyze experimental data (objective #2).

Course philosophy:

Perhaps in all endeavors, but certainly in physics classes, learning happens through practice and interaction. Specifically, we take our background knowledge, confront new situations, commit to an answer, and potentially get it wrong, ideally receiving immediate feedback. Through this, one can achieve conceptual change. Sometimes we find that our background knowledge was wrong or that we applied the wrong tool. Learning requires effort, repetition, seeking help from others, and repetition (yes, that was intentional).

The design of the class is to reduce the amount of time that you spend listening to me state things that can be found in a book, to set up a structure where you take those steps individually, and then spend the valuable class time we have discussing, dissecting, and practicing physics. The goal is that you will hit the conceptual hurdles in class, when we have the chance to sort through them and learn, and not hit those hurdles on the exam (or worse, next semester).

Class meetings and reading assignments:

I want to spend class time discussing the points that (a) are most interesting to you; and (b) are most difficult for you. I would like to avoid (as much as is possible) wasting class time discussing the easier or less interesting points that you can get from the reading or that you have already mastered in your earlier physics classes. It is therefore crucial that we are regularly communicating, both before and during class.

Reading assignments: There will be reading assignments for most classes. You must do the reading *before* class; this will allow us to spend our time working through the more challenging and interesting concepts.

Moodle "journals": you will be required to submit regular journal entries on the PHYS 221 web page on Moodle. The entries will include reflection and confusions about the reading assignments, along with any other aspect of the course that you want to discuss. I will also comment on your reflections so that there is two-way communication.

You will submit journal entries for most of the classes in which there is a reading assignment. Recognizing that there will be days when you could use a break, you will have one free "drop" for approximately every three entries.

The journal entries must be submitted no later than 9:00 a.m. on the day of the class (i.e., I need them early enough so that I can read them and incorporate them into class). That being said, it will be helpful for me (and perhaps you) if you submit them the previous night.

Equally important to being prepared *before* class, participating *during* class is key. This includes being present, engaged, and contributing to the class environment.

Laboratory:

The course includes one three-hour lab per week. The labs will complement the material covered in class. You should bring a calculator and a **lab notebook** to lab to keep data, calculations and graphs, and to record your observations and conclusions. Completion of all labs is required—*a deduction of one grade step (e.g., A to A-, B+ to B, etc) will be implemented for each lab not completed, up to a maximum of three missed labs. Four or more incomplete labs will result in an F for the course.* Having said that, there is no reason why anyone should have to take any of these penalties, as we can always make alternate arrangements if there are any conflicts with the labs, or if labs are missed due to sickness. Even unexcused misses can be made up, although there will be a smaller penalty in those cases. In case of conflict, contact me in advance if possible. If you miss a lab unexpectedly, contact your lab instructor right away and we will make alternate arrangements.

Homework:

Homework will be assigned for almost every class meeting. Half of the grade for each hand-in assignment will be based on effort – i.e., sufficient effort shown on all of the problems. The other half of the grade will be based on detailed grading of 1 or 2 of the problems. You will be able to drop your two lowest homework scores.

I will typically grade the homework and return them the next class when possible. This timing enables me to keep on top of things and identify (and address) difficulties as they develop. Because of the importance of returning the homework quickly, I will not be able to accept late homework assignments unless either (a) arrangements have been made with me in advance (e.g., for a known conflict); or (b) there is a valid reason for the lateness of the homework (I will need a letter from Student Health of from the Dean in these cases).

Concept Challenges:

We will occasionally have conceptual quizzes, typically on *new* material as a way to make sure that we are all on the same page with the foundational concepts. Conceptual understanding is the basis for quantitative work and therefore it is crucial to develop understanding of the implications of physics independent any sort of calculation. These quizzes will use a "Team-Based Learning" approach, which will be described in greater detail. Roughly though, the idea is that learning occurs through encountering a new situation, committing to an answer, perhaps getting it wrong, and then immediately getting feedback to inform your understanding. In practice, this will entail taking an individual quiz and then re-taking the exact same quiz in a team. Through team discussion, it is possible to work out the pieces of the puzzle where you are on target or have a competing pre-conception.

Exams:

There will be three in-class exams during the semester, tentatively scheduled for Friday, Sept. 18, Friday, Oct. 21, and Wednesday, Nov. 16. If there are any unavoidable conflicts, you must contact me ***before*** the exam date to make alternate arrangements. The final exam will be comprehensive.

Grading Policy:

3 Hour exams (11% each)	33%
Final exam	22%
Homework	20%
Lab	12. 5%
Concept Challenges/Team Problems	7.5%
Moodle (reading) Journal/Participation	5%

There may be a curve on final grades, but at minimum, a final average of 70%, 80%, or 90% guarantees at least a C−, B−, or A−.

Access Statement

Any student who may need an accommodation based on the impact of a disability should contact Heather Fowler, Director of the Office of Accessibility Resources at 570-577-1188 or hf007@bucknell.edu who will help coordinate reasonable accommodations for those students with documented disabilities.

Tentative Schedule Fall 2016

Please note that this is an approximate framework and the detailed schedule will be adjusted as needed.

Week	Topic	Reading	Lab
Aug. 22	**Kinematics**: 1D acceleration, coordinate systems, circular motion	1. No reading 2. Morin Ch1.1-11 Ch1.1-12 (review) Ch 1.12-22 3. Ch1.22-36	1. Intro to Mathematica
Aug. 29	**Newton's laws**: Applications of F = ma	4. Ch2.48-72 5. No reading 6. Ch2.72-77	2. Analysis of motion using numerical integration
Sept. 5	**Newton's laws**: Gravity, non-uniform accelerations, and drag	7. Ch 3.82-95, 8. Ch 3.102-110 9. Ch 3.95-102	3. Comparison of numerical approx. with experiment
Sept. 12	**Static equilibrium**: Torque and a look towards momentum and energy **Exam 1: Friday, Sept. 16**	10. May wish to review Ch 7.250-252 and Ch 1.6-8 11. No reading 12. No reading	3. (continued)
Sept. 19	**Momentum**: Center of mass, momentum conservation, rocket motion	13. Ch 4.116-136 14. Ch 4.136-151 15. No reading	4. Functional relationships from simple oscillators **Family Weekend 9/23-25**
Sept. 26	**Energy**: Conservative forces and energy conservation	16. Ch 5.162-185 17. Ch 5.185-198 18. Ch 5.198-205	8. Data fitting and residuals
Oct. 3	**Energy**: Small oscillations and collisions	19. Ch 6.212-219 20. Ch 6.219-225 21. Ch 6.225-231	5. Rotational oscillations I
Oct. 10	**Rotational motion**: Angular momentum, moments of inertia, torque	22. Ch 7.240-250 23. Ch 7.250-266	**No Lab** **Fall Recess 10/10-11**
Oct. 17	**Rotational motion**: Translation with rotation, rotational energy, rigid body motion, gyroscopes **Exam 2: Fri, Oct. 21**	24. Ch. 7.267-282 25. No reading 26. Ch. 8.292-299	6. Rotational oscillations II
Oct. 24	**Non-inertial reference frames**:	27. Ch 8.300-312,	7. Gyroscopes

	Fictitious forces	331-334 [Skipping remainder of Ch 8] 28. Ch 9.342-356 29. Ch 9.356-368	
Oct. 31	**Central force motion**: Planetary orbits	30. Ch 10.374-386 31. Ch 10.386-403 32. No reading	**No lab**
Nov. 7	**Damped, driven harmonic oscillators**	33. Ch 11.412-422 34. Ch 11.423-434 (Note. Ch 11.430-434 covers complex notation) 35. No reading	9. Driven, damped harmonic oscillators
Nov. 14	**Normal modes** **Exam 3: Weds., Nov. 16**	36. No reading 37. No reading 38. TBD	10. Driven damped electrical oscillations
Nov. 21	**Thanksgiving Break**		
Nov. 28	**Special topic: nonlinear dynamics**	39. TBD 40. TBD 41. TBD	11. Coupled oscillations and normal modes
Dec. 5	**A look ahead…**	41. TBD	**No lab** Last day of class: Tues. Dec. 6