Physics 141: Principles of Mechanics

Fall 2015

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Course Meeting times:
Section 1 MWF 10:40am-11:35am, Room: Kroehler 204
Section 2 MWF 12:00pm-12:55pm, Room: Kroehler 220
Room: Youngchild 121

Laboratory Instructors: Prof. Bloom, Prof. Gamaliy, Prof. Horner, Prof. Sinnott
Laboratory Times: T 2-4:30, T 6:30pm-9:20pm, W 1:30-4:20, R 9am-11:50am
Laboratory Rooms: Kroehler 102

CLASS WEBSITE:
https://blackboard.noctrl.edu/webapps/blackboard/execute/modulepage/view?course_id=_27657_1&cmp_tab_id=_12806_1&editMode=true&mode=cpview

Requited Text:
Physics for Scientists and Engineers with Modern Physics by Randall D. Knight, 3rd Edition.
Note, there are two options for this material 1.) Access to the eText with MasteringPhysics (ISBN 9780321753052) 2.) or the a la carte version (loose leaf, not bound) with MasteringPhysics (ISBN 9780321832825).

The MasteringPhysics course ID is MAUROPHYS1412015 (as in Instructor is Mauro; the course is Phys141; and the course is offered in 2015).

A laboratory notebook is also required (ISBN 9781930882706).

Welcome to Principles of Mechanics! In this course, we'll explore fundamental concepts associated with classical, relativistic and quantum mechanical physics. What does that mean? Well, we'll see. However, broadly, we'll work to understand the world (and universe!) around us by understanding the underlying physical concepts that govern its behavior. Some of these concepts are intuitive, but many are not. My goal is to use modern teaching techniques, informed and validated by current physics education research, to guide you through the material. This course help you to appreciate the physical universe we live in as well as help you to develop tools to excel in whatever field you decide to pursue.

Course Content and Goals

Traditionally, Physics 141 (or its equivalents at other universities) has been the first in the introductory sequence of the calculus-based physics course for non-majors. The students who take this course have very diverse backgrounds and very diverse goals. The traditional introductory physics sequence, however, has been incredibly fast-paced, covering a *HUGE* range of topics, been lecture-driven and has focused on quantitative problem solving. The main problem with this approach is that it has been shown in many peer-reviewed scientific studies (see for example Halloun and Hestenes, (1985)) to be **incredibly ineffective.**

Physics 141 represents a departure from the traditional teaching pedagogy for the introductory physics sequence. When instructors and students in other majors are polled on what their expectations are from this course we consistently come away with three main goals, which are (not coincidentally) our goals for this course:

1.) Prepare critical thinking skills for future challenges

2.) Frame physical phenomena in a way to stresses qualitative and conceptual understanding

3.) Introduce students to interesting (and dare I say fun) physical phenomena

Class Structure and philosophy

Most introductory physics courses fly through a huge number of topics. The only way to cover such a vast amount of material is a lecture-driven course where the homework is focused on quantitative problem solving. The reasoning behind this approach is that in order to become better quantitative problem solvers, one needs practice problem solving, first and foremost. However, when those assumptions are tested, it has been shown (Knight, 2004) that this approach is probably the *least* effective way to achieve the above goals. Most traditional texts are also heavily weighted toward problem solving, with the assumption that students will pick up the concepts through quantitative practice. The result is that when confronted with a problem, students equation search rather than attempt to understand the underlying physical principle. However, most problems students encounter (in and outside of a physical science context) can't efficiently be solved this way.

Quite frankly, the approach where quantitative problem solving is the primary focus is contrary to how physicists <u>do</u> and <u>think</u> about physics. Mathematics allows precision, certainly, but it occurs after conceptual reasoning. Without conceptual understanding, students can't reason their way to a solution, can't pass beyond rote memorization, and cannot proceed to develop the skills needed to solve open-ended, indeterminate, real-world problems.

Halloun and Hestenes' (1985) research informs us:

1.) Students enter not as "blank states" but with many prior conceptions.

Those prior concepts are remarkably resistant to change. Students maintain their misconceptions and <u>traditional lecture</u> is built on the notion that a student is an empty slate, and the instructor needs only supply the information.

2.) Students' knowledge is not generally organized in any coherent framework.

How could it!? Students typically only have a handful of exposures where science is presented in a rigorous way.

3.) Alternative conceptions must be altered or eliminated if students are to achieve an understanding of physics.

Halloun and Hestenes (1985) also showed that (and confirmed many times since) conceptual gains by students are independent of instructor. . . ***<u>FOR TRADITIONAL LECTURE</u>***. Results continue to show that interactive engagement teaching methods produce substantial increases in physics knowledge and problem solving gains.

Current physics education research implementation in this course

This course will not be lecture-driven in the traditional sense. I won't be spending class time lecturing back the book to you, the passive student. Current physics pedagogical research informs us that the most effective way to teach physics is to focus on the conceptual underpinnings in an *active environment*. This means that class time will usually be broken down into smaller segments, approximately 15 minutes in length, and each segment will focus on developing your conceptual understanding of a key physical principle. We'll spend 7-10 minutes discussing the principle through example and demonstration. Then we'll enter a period of peer instruction: A conceptual question (a concepTest) will be posed to you designed to test your understanding; you'll take a few minutes to discuss the problem and convince your neighbor that your solution is correct. The class will be anonymously polled and we'll discuss one might approach the problem.

Obviously, this represents a departure from the stereotypical physical class. But I want to stress again, this approach has been shown to be a more effective pedagogical approach than traditional lecture where students are essentially passive observers during class time. In this class, you will be an equal partner in your own education. As you may have gathered, we couldn't possibly cover the same number of topics as a traditional curriculum. However, at the end of the year, we will have 1.) Covered all the topics which natural science instructors expect from the introductory physics sequence, 2.) Covered nearly all the topics on standardized tests such as the MCAT and 3.) Approached the material in a way that consistently increases students' problem solving skills and physics IQ. Because the number of topics have been reduced we've adjusted content and pace to best match what the available physics education research tells us is the most effective approach.

<u>Physics 141 has the following key components:</u>

Readings: Reading assignments for each day in the schedule are to be done BEFORE class starts. I expect you to read through the assigned reading. I reiterate- I WILL NOT lecture from the text. I will not cover each piece of material from the text during class time. Our time in class is focused on developing your conceptual understanding of the important physical principles. However, even if material isn't explicitly covered in class THE MATERIAL IS STILL FAIR GAME FOR THE TEST. I won't waste time on extensive definitions from the text. This implies that you can't read or think for yourself and you should be offended. Additionally, substantial research has shown (see Van Huevelen, 1991a and 1991b for instances) that devoting class time to re-presenting the material from the text doesn't enhance learning.

You are an equal partner in your own education- If you don't do the assigned reading, you're not holding up your end.

Reading Quizzes: To further encourage you to read the text, there will be short Moodle reading quizzes based on the reading due for the class period. You must complete these quizzes by 12:00a.m. (Midnight) the night before class. Most of these quizzes will be short, multiple choice, and designed to make sure that you've done the reading and not that you've comprehended the deeper meaning of the material. You may use your book for these quizzes but you must do them on your own. You will have 10 minutes to complete the quiz. Your lowest quiz score will be dropped and I will drop the next lowest quiz score if you come to my office at least once during the term. COME TO MY OFFICE HOURS TO TALK PHYSICS!

Class Time: You must attend class. This is the time when we do the heavy lifting of the course together. I've designed our time together for you to get the most bang for your buck. I won't waste your time by standing up at the black board boring you to sleep. Your end of the deal is showing up. Participation will account for a percentage of your final grade. While I won't be taking attendance in class I reserve the right to administer so-called "Lecture Tutorials." Lecture Tutorials are brief group exercises in which you and one or two partners will complete and extended example problem. The group will turn in the exercise DURING CLASS TIME and you will be assigned a grade: you will score a 2 for a good faith attempt at the tutorial; you will score a 1 for a poor attempt at completing the tutoring; you will receive a 0 if you don't turn in a tutorial or arrive late for the tutorial. Tutorials will be administered at my discretion without any advance warning. COME TO CLASS.

Because this course has a laboratory associated with it, you and I have 165 officially together each week. We'll meet Monday, Wednesday and Friday for 55 minutes. On Monday and Wednesday, we'll engage the material with a combination of discussion, interactive conceptual quizzes, lecture tutorials, and other, yet to be determined work. On Friday of each week, we'll either be engaged in a **Workshop Session** or a dedicated **Problem Solving Session**. In the former, you'll work in a small group to complete a guided worksheet that tackles a potentially tricky topic from class. In the latter, we'll work through a series of problems together sometimes breaking out into groups and then presenting for the class.

Refer to the schedule for details on when we'll be in workshop and when we'll be solving problems. On all days where the class meets, we'll meet together for 55 minutes but I'll remain to answer questions for the 15 minutes rounding out the 70 minute time slot.

Peer Instruction: At the heart of my pedagogical philosophy is the importance of conceptual understanding. Each class period is broken up into a number topical discussions followed by a concepTest. The concepTest gives me feedback about how you have grasped a particular concept. CONCEPTESTS ARE NOT GRADED! ConcepTests by their very nature require peer-to-peer interaction and discussion. Research has shown (Mazur, 1997) that it is very common that in a pair of students during peer instruction, one student has a better grasp on the concept than the other. RESEARCH ALSO SHOWS THAT THIS DIFFERENCE IN CONCEPTUAL UNDERSTANDING IS NOT A REFLECTION OF INHERENT ABILITY. THIS DIFFERENCE IS A REFLECTION OF DIFFERENT BACKGROUNDS.

Research also shows that during peer instruction, both people improve their understanding of the concept by attempting to explain their positions during the concepTest. This pedagogical approach relies on all students taking part in the peer instruction. I want to make it absolutely clear that your peers' grades in the course HAVE NO IMPACT ON YOUR GRADE. GRADES ARE DETERMIEND ON AN ABSOLUTE SCALE. Thus there is absolutely no incentive for you not to participate. Your grade will not be determined based on a curve and grades will not be scaled at the end of the course. While the average grade in this course has traditionally hovered around a B there is no reason why it can't be an A.

Homework: This course requires reading of the textbook prior to class and because of this I've attempted to reduce the amount to homework so as to not overwhelm you the student. There will be seven homework sets of (what I think of as) reasonable length. There will be a mix of conceptual and quantitative problems. On the first day of class I'll discuss the grading methodology for homework problems. While class time is heavily focused on conceptual understanding and qualitative problem solving homework problems will also require significant computation. Homework problems will discourage formula seeking. <u>A focus on qualitative analysis over quantitative analysis, in an active-learning environment, somewhat counter-intuitively, results in students doing better with basic quantitative problem solving (Hake, 1998).</u> As such, while you will get less practice in class with quantitative problem solving, your skills will improve *faster* than in traditional lecture.

Examinations: There will be one midterm and a final in this course. Many of the exam questions will be based on homework, reading quizzes, ConcepTests, and Lecture Tutorial questions; the rest will be based on your readings and the lab exercises. The final examination will be cumulative, while emphasizing material covered since the third test. Exams will be closed book and closed notes. Quite frankly, if you spend all your study time memorizing equations and formulae, you will not do well on the exams. I care so very little about the final numerical answer that it will be a shockingly small fraction of the point total for any given exam question. I want to test your ability to break down a problem into its most basic elements, qualitatively understand the problem and potential solutions, and check to see that your solution makes sense. Because I wish to discourage equation seeking and memorization of equations, I will provide you with an equation sheet containing all the equations you'll need. I'll make copies of this equation sheet available for you well in advance of the exam; however, you won't be allowed to bring any notes to the exam itself and fresh equation sheets will be provided at the exam. You may use a calculator for any necessary computation, but you will not be allowed to store information in it that may be potentially useful on the exam. You may not use a cell phone, PDA, smart phone, or any other device that could connect to the internet as your calculator. If you don't have a calculator, I'm more than happy to provide one to you.

The use of Calculus:

"To those who do not know mathematics it is difficult to get across a real feeling as to the beauty, the deepest beauty, of nature... If you want to learn about nature, to appreciate nature, it is necessary to understand the language that she speaks in."

—*Richard Feynman (The Character of Physical Law (1965) Ch. 2)*

*C*alculus it is requisite for this course and but quite frankly the mechanics of calculus isn't a focus of this course. Rather, we'll use functional calculus to help us to understand physical phenomena and hopefully we'll begin to "think with calculus." This applies to other mathematical topics that will appear in this course, such as vectors.

Weighting: All exams are closed book and closed notes. Unless I say something along the lines of "you won't need to remember this," assume that you will, in fact, need to remember it. You may use a calculator on exams, but ONLY FOR COMPUTATION. You are NOT allowed to store information or connect to the internet with devices such as PDA's.

LABORATORY EXERCISES: Eight times during the term you will meet in one of four separate laboratory sections (see schedule). We will discuss the labs in more detail when we have our first meeting.

COURSE GRADE:	
Participation	5%
Reading Quizzes	5%
Homework	30%
Laboratory	20%
Midterm Exam	20%
Final Exam	20%
Total Grade	100%

Grades are determined on an absolute scale. This is done to encourage peer instruction and interaction and to discourage an ultra-competitive atmosphere in class. A = 100-90%, B = 89-80%, C = 79-70%, D = 69-60%, F = 59% and lower. I set no quota for the number of grades I hand out; I would be ecstatic and pleased beyond all reasonable measure to give all A's to a class that earned it.

COMMUNICATION: An important asset in any field is the ability to communicate your ideas clearly. With this in mind, I expect all homework, quiz and exams to be written legibly and presented neatly. Plots and figures MUST be labeled accurately and captioned if necessary. Finally, your answer to any question MUST include the appropriate units, if applicable. This is crucial not only to conveying an answer intelligibly, but also to checking the validity of your answer; after all, if you find that an electron has a speed of 25 kg/m, you know something must be wrong!

ATTENDANCE & MAKE-UP POLICY: Attendance is extremely important in this and all classes, given the 10 week pace of the term, and the extensive ground we will cover in that time. Attendance will be measured informally as well as through such activities as the Lecture Tutorials. All assignments are due on the day given in the class schedule. Make-up midterms will be possible ONLY if I am notified prior to the exam AND I approve the excuse. Any make-up exams are to be taken before the date listed on the syllabus.

ACADEMIC DISHONESTY: Academic dishonesty of any sort will not be tolerated. Academic dishonesty includes, but is not limited to, plagiarism, cheating on exams, falsifying experimental data, and providing unauthorized aid to another student. When working with others, or receiving help from CTL tutors, you must include an acknowledgement of those with whom you worked. That includes me.

ADA AND ANTI-DISCRIMINATION STATEMENT: In compliance with the Americans With Disabilities Act (ADA), all qualified students enrolled in this course are entitled to reasonable accommodations. It is your responsibility to contact student academic services to work out accommodations. Please note, this must be done on a course by course basis, i.e., you must discuss specific accommodations for this course. I'm happy to discuss any of these issues with you at any time, BUT, do not come to me the day before the exam and request accommodations. I am strongly committed to ensuring that the antidiscrimination policy established at NCC will be honored in my class.

References

I. A. Halloun and D. Hestenes, "The initial knowledge state of college physics students," *Am. J. Phys.* **53,** 1043-1055 (1985).

R. D. Knight, *Five Easy Lessons- Strategies for successful Physics Teaching*, Addison Wesley, San Francisco, CA, 2004.

A. Van Huevelen, "Learning to think like a physicist: A review of research-based instructional strategies," *Am. J. Phys.* **59**, 891-897 (1991a).

A. Van Huevelen, "Overview, Case Study Physics," *Am. J. Phys*. **59**, 898-907 (1991b).

E. Mazur, *Peer Instruction: A User's Manual*, Prentice-Hall, Upper Saddle River, NJ, 1997.

R. R. Hake, "Interactive-engagement vs. traditional methods: A six-thousand student survey of mechanics test data for introductory physics courses," *Am. J. Phys.* 66, 64-74 (1998).