

PHY 3110

(Advanced) Classical Mechanics

Dr. Aaron Titus

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Fall 2014

Course meets: MWF, 9:15 – 10:25 AM and TH 3:15–5:15 PM, 129 Congdon

Office Hours: 361 Congdon (336-841-4668) or 129 Congdon

MW 10:30–11:30 AM, TTh 1:30–3:00 PM

<http://physics.highpoint.edu/~atitus/courses/phy3110/>

1 My Personal Mission Statement

My personal mission is to encourage you to be a life-long, interdisciplinary learner. If you are teachable, motivated, and diligent, you will be successful.

My educational philosophy is that you learn best when you are actively engaged with the subject through activities such as reading (and answering questions about what you read), discussing, experimenting, and solving problems. Lectures are useful for motivation and synthesis, but for most students merely listening to lectures and copying lecture notes is an ineffective method to learn. It's when you study individually, think deeply about the subject, ask questions, develop ideas and test them, and subsequently dialogue with classmates and the professor that you learn the most. My role as the professor is to create an environment that promotes active-learning, to assess your learning, and to provide guidance and mentorship along the way.

I expect you to learn the tools of scientific exploration that we will use in this class, including mathematical methods, laboratory methods and equipment, and computational modeling. In this course you will do an independent project. I hope that you will better understand the nature and process of science as a result of taking this course.

I reserve the privilege to change this syllabus based on feedback from you and what I determine is best for the course. If the syllabus is updated, I will place an updated electronic copy of the syllabus on our web site.

2 Introduction to the Course

PHY 3110. Classical Mechanics. An advanced study of Newtonian mechanics applied to particles and systems of particles. Topics include central force motion, oscillators and coupled oscillators, rotating systems and rigid bodies, calculus of variations, and the Lagrangian and

Hamiltonian formulations of mechanics. Prerequisites: PHY 2020, MTH 2410, and MTH 3410 (MTH 3610 may be taken in place of MTH 2410 and MTH 3410). This course is offered in the fall of even-numbered years and consists of 6 hours of integrated lecture and laboratory per week. Four credits.

2.1 Expectations

Expect to work hard, to be challenged, to learn, and to work together. Expect to break through any struggles, doubts, and challenges, gain new abilities, accomplish new tasks, and develop analytical reasoning skills. **Expect to be lovingly pushed out of your comfort zone.**

2.2 Learning Outcomes

Upon completion of the course, you can make the following statements:

1. I can apply fundamental principles of mechanics to solve problems relating to a particle, systems of particles, a two-body system, and a rigid body.
2. I can apply Hamilton's Principle and can identify problems in which it is optimal for solving the problem.
3. I can use appropriate mathematics including algebra, calculus, vector algebra, linear algebra, and differential equations.
4. I can write Python code to model a physical system.
5. I can conduct an experiment and express my results in a professional paper.
6. I can ask an interesting question in mechanics and can apply theory, analytically and computationally, to answer the question.

2.3 Standards-Based Grading

In this course, I want to encourage you to be a life-long learner. This requires that you develop a growth mindset. In other words, I want you to be driven by answering interesting questions, making reasoned arguments, and developing new skills and knowledge independent of grades and test scores. As a result, I will use a grading system called Standards-Based Grading (SBG) which determines grades based on your demonstration of skills and knowledge at the end of the semester and does not penalize you for not having those skills and knowledge at the beginning of the semester. In my opinion, SBG incentivizes growth instead of performance.

Instead of getting numbers, or letters, on exams that average into a final grade for the course, there are a set of standards on which you are expected to show improvement throughout the semester. I will give regular quizzes that assess some subset of these standards, and

on each standard, you will receive a number from zero (“does not demonstrate the standard”) to 4 (“demonstrates sufficient mastery of the standard”). Each standard will be assessed multiple times on multiple quizzes. Your most recent score on each standard is recorded. In this way, as you improve, early poor scores will not impact your grade.

Table 1 lists the standards for theoretical topics that will be assessed in this course. Table 2 lists the standards for skills that will be assessed in the course. Each of these standards is tied directly to the learning outcomes. Every quiz will provide an opportunity to demonstrate understanding of certain standards. These may or may not be explicitly stated beforehand. Not all standards will (or can) be assessed by every quiz.

You can track your progress through the course web site. At the end of the course, your final grade will be assigned based on your performance in demonstrating the theoretical understanding and skills defined by the standards. If you have not demonstrated a 4 in at least five “theory” standards, you will receive a D. A C will correspond to demonstrating at least 10 theoretical standards and one skill (with a 4). To receive a B, you must demonstrate at least 15 theoretical standards and three skills (with a 4 on each standard). To get an A, you must demonstrate all the theoretical standards and at least four skills. Table 3 presents in detail how the final grade is derived from the list of standards.

I reserve the right to count multiple higher standards in place of one lower standard if it is in the student’s best interest.

2.4 Pedagogy

I will use modified problem-based learning to teach the course. You will have extensive on-line tutorials, videos, examples, and reading assignments before you come to class. During class, we will work collaboratively to solve one or more problems. After class you will have homework on the same topic. There will be few lectures.

We will have a weekly lab in which you will develop experimental skills and proficiency with error analysis.

2.5 Textbook

We will use *Classical Mechanics*, by John Taylor. However, I will provide references to other books.

3 Assignments

There will be five types of assignments for this course.

1. Homework
2. Quizzes

Table 1: Assessed Standards for Theory

Type	Number	Chapter	Name	Standard
theory	1	1	N2L	I can describe Newton's laws and can apply Newton's second law in a Cartesian coordinate system.
theory	2	1	N2L-polar	I can describe Newton's laws and can apply Newton's second law in a polar coordinate system.
theory	3	2	vdepforce	I can apply Newton's second law to a system that has velocity dependent forces.
theory	4	3	P-cons	I can describe conservation of momentum and can apply it to systems of particles.
theory	5	3	L-cons	I can describe conservation of angular momentum and can apply it to systems of particles.
theory	6	4	Work	I can write the energy of a particle and a system of particles. I can apply the work-kinetic energy theorem to a particle, and I understand the assumptions of this theorem.
theory	7	4	PE	I can state the conditions required for a force to be conservative. I can interpret a $U(x)$ graph.
theory	8	4	E-cons	I can apply conservation of energy to both open and closed systems, with both conservative and non-conservative forces.
theory	9	5	SHM	I can identify and analyze a harmonic oscillator. I can analyze a damped and/or driven oscillator.
theory	10	5	Fourier	I can write a periodic function as a Fourier series. I can find the Fourier frequencies of a periodic function.
theory	11	6	Euler-Lagrange	I can state and apply the Euler-Lagrange equation.
theory	12	7	Lagrange	I can state Hamilton's Principle and can apply it by calculating Lagrange's equations with generalized coordinates.
theory	13	7	Hamiltonian	I can define the Hamiltonian of a system.
theory	14	8	CM	I can analyze the motion of a system in terms of the motion of the CM and motion relative to the CM.
theory	15	8	2-Body	I can analyze a 2-body problem as an equivalent one-dimensional problem.
theory	16	9	non-inertial	I can apply Newton's second law in a non-inertial reference frame with linear acceleration.
theory	17	9	Coriolis	I can apply Newton's second law in a rotating reference frame.
theory	18	10	rot-inertia	I can calculate the moment of inertia tensor for a rigid body rotating about a given axis and can define and determine the principal axes.
theory	19	10	rot	I can apply Euler's equations to a rigid body.
theory	20	11	modes	I can find the normal modes for a system of coupled oscillators.

Table 2: Assessed Standards for Skills

Type	Standard
diligence	I can solve at least 90% of the homework problems.
computation	I can write code in Python to model a physical system.
math	I can use appropriate mathematics including algebra, calculus, vector algebra, linear algebra, and differential equations.
lab	I can conduct an experiment and express my results, including error analysis, in a professional paper.
project	I can ask an interesting question in mechanics and can apply theory, analytically and computationally, to answer the question.

Table 3: Grading Algorithm

Grade	Demonstrating a 4 on
F	fewer than two theoretical standards and no skills.
D	fewer than five theoretical standards and no skills.
C-	at least five theoretical standards and one skill.
C	at least ten theoretical standards and one skill.
C+	at least fifteen theoretical standards and one skill.
B-	at least fifteen theoretical standards and two skills.
B	at least fifteen theoretical standards and three skills.
B+	at least fifteen theoretical standards and four skills.
A-	all twenty theoretical standards and four skills.
A	all twenty theoretical standards and five skills.

3. Re-assessments
4. Final Exam
5. Lab Reports

Each of these assignments will be explained in further detail below.

3.1 Homework

Homework is the primary method by which you will learn to apply theory and develop your problem solving skills and computational modeling skills. You will post photos or scans of your hand-written solutions on the course web site. You do not have to get every problem correct. But rather, you must give a strong attempt to more than 90% of homework problems in order to satisfy the “diligence” standard.

3.2 Quizzes

There will be approximately 1 quiz for every 2 or 3 class days. Some quizzes will be take-home. Problems will be associated with standards and your scores on the standards will be recorded.

3.3 Re-assessments

You may ask me at any time to re-assess a certain standard. The first re-assessment must be within two weeks of the first assessment. No re-assessments will be accepted after Dec. 17.

3.4 Final Exam Period

During our final exam, you will be allowed to select the three (or maybe four) problems out of ten. Our final exam is on Monday, December 15, 8–11 AM.

3.5 Lab Reports

Your lab report must be written in LaTeX using the style that I will give you.

4 Course Policies

4.1 Credit Hours

In addition to attending class, students are expected to spend at least 2 hours each week engaged in out-of-class work (i.e., reading, studying, doing homework, working collabora-

Table 4: Credit Hour Justification

Activity	Weekly Time (minutes)	Total for Semester (minutes)
Lecture and in-class activities (synchronous)	200	3000
Homework/reading (asynchronous)	480	7,200
Lab (synchronous)	120	1800

tively, etc.) for every hour of credit earned in this course. Table 4 outlines the minimum amount of time you should expect to spend per week and per semester both in and out of class. However, in reality you will spend much more time on the course than this due to the difficulty of the course.

4.2 Attendance Policy

During class, you will solve problems collaboratively. If you have three absences, you can be placed on class attendance probation and can be withdrawn from the class upon further absences. I reserve the right to choose whether to withdraw you or not for lack of attendance.

4.3 Honor Code

The High Point University Honor Code asserts that:

- Every student is honor-bound to refrain from conduct which is unbecoming of a High Point University student and which brings discredit to the student and/or to the University;
- Every student is honor-bound to refrain from collusion;
- Every student is honor-bound to refrain from plagiarism;
- Every student is honor-bound to confront a violation of the University Honor Code;
- Every student is encouraged to report a violation of the University Honor Code.

My obligation is to promote academic integrity and to enforce the University Honor Code. This obligation includes appropriately interpreting the Honor Code, promoting conditions favorable to academic integrity, and reporting violations of the Honor Code. I encourage collaboration on homework. You must do quizzes, the final exam, and re-assessments on your own. Violation of the honor code will be handled according to procedures outlined in the *Faculty Handbook*.

4.4 Accommodations

Students who require classroom accommodations due to a diagnosed disability must submit the appropriate documentation to Disability Support in the Office of Academic Development, 4th Floor Smith Library. A student's need for accommodations must be made at the beginning of a course. Accommodations are not retroactive.

5 Acknowledgements

Ideas for SBG have been learned from Andy Rundquist, Frank Noschese, and Josh Gates.