PHYS 321 **CLASSICAL MECHNICS** **Spring, 2018**

SYLLABUS

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Time: MWF 2:00-2:50 pm

Office hours: To be decided later

Text: Classical Mechanics
by John R. Taylor
University Science Books, 2005

Course Objectives

In this course, we will study the principles of classical mechanics, mostly the mechanics of particles. You can observe mechanical phenomena using your natural senses, thus direct experience helps intuition in most situations. Consequently, mechanics is the ideal place to learn how to describe a phenomenon using plain text, sketches, graphs, equations, and various forms of mathematical evaluation and combine them into a complete description as needed and desired for complete understanding of a situation.

The fundamental laws of classical mechanics have not changed since Newton published the "Principia" in 1687, although new – but equivalent – formulations were developed by Lagrange and Hamilton later. We know the limits of applicability: Classical mechanics should not be used, if the velocity is close to the speed of light, or to describe the motion of atoms and other very small objects. But even the theories that are applicable in those cases (relativity and quantum mechanics) are well developed, thus classical mechanics stands on extremely solid foundations.

We will study a rich variety of simple and complex phenomena, from the falling of a ball to the motion of satellites and the coupled motion of several particles. As the basic physics of all those cases is contained in Newton's laws, we are free to focus on mathematical methods and the delicacies of interpreting the results obtained by either analytical evaluation or numerically.

Book and quizzes

Our textbook, Taylor's "Classical Mechanics" is clearly written and easy to read. Therefore, I will focus on the basic principles and tricky points of the derivation in class. We will also work out problems. Much will be left for reading; take it seriously. Read the assigned sections to the last dot. Literally. The schedule at the end of this Syllabus shows approximately how far to read at any time during the course. There may be slight deviations, but I will always let you know at least how far to be with your reading. Occasional unannounced pop-up quizzes will be used to test whether you keep up with your reading assignment. But more important than that, I will assume during lecture, that you will have read certain sections. If not, the lecture will be less effective. You are always allowed to read ahead, but do not fall behind.

Assessment

PHYS 321 is one of the courses included in the Physics Department's Learning Outcomes Assessment Plan. It specifically sets the objective that student in this course develop the ability to:

1. Use Newton's laws to set up and solve a range of physical problems.
2. Exhibit an understanding of energy conservation, potential energy, conservative and central forces, conservation of momentum and angular momentum, and use it to solve a range of physical problems.
3. Set-up and solve problems related to driven and damped oscillations, along with coupled oscillators and normal modes of oscillation.
4. Use the Lagrange formalism to find and solve the equations of motion for mechanical systems.
5. Develop an understanding of rigid body rotational motion and use it to solve related problems.
6. Understand and solve problems related to the two-body central force problem.
7. Show an understanding of mechanics in non-inertial reference frames and use it to solve related problems.

Homework

There will be a homework assignment every week, due on Friday before the beginning of class. Late homework will be accepted until the start of the next lecture, for 50% credit. Solutions to every problem have to be submitted. They must be clearly written, legible, complete with mathematical evaluation, computer printout, and verbal comments as appropriate. The solution must be **complete**; I must be able to follow your logic and evaluation line-by-line, equation-by-equation. A summary or sketch of the solution is not acceptable. The final result of a solution is always a statement, a **verbal** answer to the question, not a formula or a value without explanation or interpretation.

Some problems will be relatively simple and straightforward, others will require several pages of evaluation or numerical solution. Some simple-looking problems may turns out to be quite hard and long. Therefore, start the homework early. That also gives you time to look for help if needed.

You can learn how to solve problems only by working out many-many problems in full detail. There is no easy way or shortcut. Reading somebody else's solution is not a substitute. Euclid told King Ptolemy when he asked for an easy way to learn mathematics that "there is no Royal Road to geometry." That happened around 300 BC, but his words are as valid today as his geometric principles. If you want to be able to work quickly and without mistakes, practice, practice, practice. No shortcuts, no excuses.

You are allowed, in fact, encouraged, to form study groups and discuss the material and homework questions with each other. But at the end, the homework solution must be your own work, not a group product. I will give no credit for obvious copies. After all, you are left to your own devices at the tests and in real life. You can learn from each other, but be able to work on your own. Get hints, exchange notes, but solve the problems yourself.

Many homework problems will be from Taylor. It is a popular book, consequently solutions to its problems can usually be found on the web. Use the web sparingly and only as a last resort for clues or to double check the result. If you cannot solve the problems, you cannot pass the tests either. Direct copying from the web, with or without naming the source, is not allowed. (Without reference it is also plagiarism, a form of academic misconduct.) Many solutions on the web are not up to my standard; some are outright incorrect. Leaving out a few lines, adding a few obvious intermediate steps, and changing notation do not make a copy less of an infringement. Identified copies do not get credit. The best strategy is leaving the web solutions out of your set of tools entirely.

A typical homework assignment will consist of 8-10 problems depending on the degree of difficulty. I will grade one (or two short) problems to meticulous detail, the rest only for good faith effort. Sample solutions will be posted for every problem, usually after Monday's lecture.

A few homework problems may benefit from some simple numerical work, such as solving a differential equation, plotting a function, or determining the eigenvalues of a matrix. Any of those can be done with a few lines of code in Mathematica. I assume that most of you are familiar with it on a basic level. Numerical methods and programing are not a subject of this course, you can easily get an A with only analytical solutions.

Tests

There will be two in-class tests during the semester plus a cumulative final. The material covered after the second midterm will be represented on the final with a somewhat heavier weight than its relative length suggests. The tests are closed book. If I ask a question that requires the knowledge of anything but the most fundamental physical or mathematical results, I will provide that as part of the question. If you need a formula that is not provided, ask. (But you need to know exactly what you are asking for.) The objective of the course is not to memorize formulas, but to understand their meaning and how to operate them.

If you miss a test for medical or other unavoidable reason, provide proof, and we will arrange for a make-up test. If you know that you will have to miss a test for a foreseeable reason (religious holiday, court date, family event, existing medical problem), make arrangements well before the test, rather than after.

Grades will be determined according to the following distribution:

Two midterm tests	100 each	=	200
Final exam	200 each	=	200
Homeworks (about 12)	20 each	=	240
Pop-up quizzes (about 12)	5 each	=	60

That adds to a maximum possible total of 700. Approximately, A will be given above 80%, B for at least 68%, C for at least 55% of the actual maximum achievable total.

I will show detailed grade statistics after each test. It will tell you the grade you would receive if I had to assign it at that moment. It will also show how far you are from obtaining a better grade or from slipping. If at any moment you are uncertain about your standing, ask. In particular, do not withdraw from the course for fear of a bad grade without consulting me first. Your chances may be better than you think.

"Incomplete" is given only in exceptional cases. To be considered for an "I", you must have taken the first midterm test, submitted 8 sets of homework solutions, and have C or better standing at the time of incapacitation.

Academic Integrity

"By enrolling in this course, each student assumes the responsibilities of an active participant in UMBC's scholarly community in which everyone's academic work and behavior are held to the highest standards of honesty. Cheating on a test could result in disciplinary action that may include, but is not limited to, suspension or dismissal." More on the requirements of academic integrity can be found at http://www.umbc.edu/gradschool/procedures/integrity.html

Applied to this course, a proven case of misconduct during a test or a blatant copy or plagiarism of a homework solution "earns" zero on the assignment in question. A second offence will result in failing the course.

On my end, I promise well-prepared lectures, careful and timely grading, and openness.

Questions and Comments

If you have any question, concern, or suggestion during the semester, do not hesitate to talk to me. Although I have a jar labeled "Ashes of Problem Students" on my desk, it is empty and I do not intend to fill it any time soon. Do not wait until the end of the semester. Comments on the blue sheet help next year's students but not you.

I will have office hours at a time when most of you are available. You can also drop in with a short question, comment, or request at any time, although I may not always be available. If you need more one-on-one attention, schedule an appointment.

Efficient discussion of physics requires working out equations, drawing graphs, etc. It cannot be done in an email or on the phone. See me with technical questions. Use the phone or email (preferred) to let me know if you cannot attend a class or to schedule an appointment. You can also email any comment or concern. Although I prefer meeting in person, I understand that some subjects may be uncomfortable or you may want to make sure that your comments are precisely worded, recorded, and clearly understood.

Blackboard

Assignments and sample solutions will be posted on Blackboard. I may also post announcements if necessary, such as canceling a class due to inclement weather, changes of an assignment, etc. In those cases, I will also email you. I will enter your grades into Bb, thus you can see whether all your grades are recorded correctly. Make sure to check occasionally and resolve any mistake as soon as possible.

Disabilities

- If you have any condition such as a physical or learning disability, which will make it difficult for you to carry out the work as described or which will require academic accommodation, please notify me ASAP, but definitely during the first two weeks of classes.

- If you are taking the exam with Student Support Services, remind me by email 48-96 hours before *every* exam to give me time for proper preparation. You also need to schedule the exam with Student Support Services.

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SCHEDULE

The book sections listed refer to Taylor. You are encouraged to read through the sections quickly ***before*** each lecture. Read them again carefully after the lecture.

Although minor adjustments to this schedule may be necessary, I will try to cover all the included subjects, even if it requires skipping some details.

Date	Reading	Subject
1.29.	1.1-5	Introduction, Newton's laws, 1-d and constant force
1.31.		Systems with more than one object
2.2.	1.6	Newton's law problems in Cartesian coordinates
2.5.	1.7	2-d polar coordinates, problems
2.7.	2.1-4	Projectile motion with drag
2.9.	2.5-7	Charged particle in a magnetic field
2.12.	3.1-3	Momentum, center of mass
2.14.	3.4-5	Angular momentum
2.16.	4.1-5	Work, kinetic energy, potential energy
2.19.	4.6-8	1-d and central force problems
2.21.	4.9-10	Energy of multi-particle systems
2.23.	6.1-3	Calculus of variations
2.26.	6.4	More than two variables, problems
2.28.	7.1	Lagrange's equations
3.2.	7.2-4	Constrained systems
3.5.	7.5	Problems
3.7.		Review, test preparation
3.9.		**Test #1**
3.12.	7.6-8	Generalized momenta, conservation laws
3.14.	7.10	Lagrange multipliers; review
3.16.	8.1-2	Central force, reduced mass
3.19 - 3.23.		SPRING BREAK
3.26.	8.3-5	The equation of motion
3.28.	8.6-7	Kepler orbits
3.30.	8.8	Changing orbits
4.2.		Planetary motion problems
4.4.	9.1-2	Accelerating reference frames
4.6.	9.3-5	Rotating reference frames
4.9.	9.6-7	Centrifugal and Coriolis force
4.11.	9.-10	Applications
4.13.	10.1	Center of mass
4.16.	10.2-3	Rotation about a fixed axis, angular inertia tensor
4.18.	10.4-5	Principal axes of inertia
4.20.	11.1-4	Coupled oscillators with two degrees of freedom

4.23.	11.5-7	Coupled oscillators, normal coordinates
4.25.		Review, problems
4.27.		**Test #2**
4.30.	13.1-3	Hamilton's equations
5.2.	13.4-6	Phase space orbits
5.4.	13.7	Liouville's theorem
5.7.	14.1-3	Scattering, cross section
5.9.	14.4-5	Differential cross section
5.11.	14.6	Rutherford scattering
5.14.		Review, test preparation