Phys 4001 | **Classical Mechanics** | **Fall 2011**

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Office hours: M,W,F 10; Tu,Th 12; You're welcome to try at other times when my door is open, or make an appointment.

Prerequisites Classical Physics (Phys 2022), Differential Equations (Math 3280)

Text *Classical Mechanics*, by John R. Taylor.

Additional references A variety of other texts exists on the subject of mechanics at a level comparable to the chosen text. Some are older standards, others more recent. These include *Mechanics* by Symon, *Classical Dynamics of Particles and Systems* by Thornton and Marion, or (Marion and Thornton, or just Marion, depending on edition), *Classical Mechanics* by Chow, and *Introduction to Classical Mechanics* by Arya. While the text has useful mathematical relations on the inside covers and all sorts of mathematical info can be found on the web, a mathematical handbook one can browse may also prove helpful. One such inexpensive reference is *Mathematical Handbook* by M. R. Spiegel, in the Schaum's Outline Series.

Course content We will begin with a review of basic principles of classical mechanics (chapters 1-4). This will be a slightly more formal and mathematically comprehensive treatment of ideas presented in general physics. Problems only briefly touched upon there will be re-visited in more detail. We will omit chapter 5 on oscillations since this was covered extensively in Phys 2022 (although be aware we will deal with coupled oscillators later in the course, so you might want to review this material independently as a refresher). Alternatives to the Newtonian formulation of mechanics will then be taken up, in particular Lagrangian mechanics and Hamilton's principle (chapters 6-7). This will be followed by a sampling of applications, from chapters 8-11: motion and orbits under central forces, rotation (non-inertial frames, rigid body motion), and coupled oscillators. Non-linear phenomena or Hamiltonian dynamics (chapter 12 or 13) will be examined only as time may permit.

Grading Course grades will be based on these contributions and associated weights.

- Homework and in-class problems or quizzes 35%
- Tests (2) 35%
- Final exam 30% (scheduled for Saturday, December 17, at 10:00 A.M.)

The expected grading scale is: $> 85\%$ ⇒A-,A; $> 70\%$ ⇒B-,B,B+; $> 55\%$ ⇒C-,C,C+; $> 45\%$ ⇒D,D+.

Homework Reading and problems will be assigned regularly. Be prepared to discuss in class the assigned readings and problems. Little will be learned here without extensive practice through working problems. A subset of assigned problems will be designated for handing-in. Satisfactory homework solutions must include complete development of mathematical aspects and brief English explanations of the reasoning that guides your method of solution. See the description of homework requirements. You are encouraged to discuss problems with your classmates; all work you submit must, however, be your own - be prepared to explain it to others.

Problems where you are asked to "prove" a mathematical result require a formal sequence of simple logical steps, each of which is defensible by a supporting mathematical principle easily recognized or cited. While all problems are expected to proceed logically, proofs require a demonstrable justification of each step and are generally more formal in these requirements.

Software packages can be employed to attack problems requiring *numerical* approaches. *Symbolic* manipulations must be done without recourse to software tools, as developing facility with choosing the appropriate techniques to solve problems is an important skill to be gained from the course. This means, for example, using Mathematica to do some algebra or calculus for you is generally not acceptable, but exploiting its numerical routines to solve a non-linear differential equation could be.

Homework submitted after 5 pm on the due date but within 2 days will be accepted but considered late and subject to a 50% discount; one exception to this will be permitted during the semester.

Submitting work based wholly or in substantial part on the work of others, including solution manuals or solutions posted in other ways is unacceptable. Infractions are governed by the campus-wide academic integrity policy http://www.d.umn.edu/conduct/integrity/

Homework grading scale 1-5:

1. = some evidence that an actual attempt at the problem was made.
2. = solution has major flaws.
3. = possibly or even probably correct, but little effort made to make the solution logical and coherent for another person to read and understand, or may have significant flaws or omissions.
4. = correct solution, clear effort made to explain reasoning but could be improved by more attention to organization and presentation, or may have a minor flaw, but clearly presented so error is easily detected.
5. = correct and convincingly presented solution, with reasoning explained and well organized.

Individuals who have any disability, either permanent or temporary, which might affect their ability to perform in this class are encouraged to inform the instructor at the start of the semester. Adaptation of methods, materials, or testing may be made as possible to provide for equitable participation. Please contact the Office of Disability Resources to discuss and arrange reasonable accommodations. (KSC 258, 218-726-6130, or visit the DR website at www.d.umn.edu/access for more information.)

Links to other relevant campus policies:
http://www.d.umn.edu/vcaa/TeachingLearning.html
http://www.d.umn.edu/vcaa/FinalExams.html
http://www.d.umn.edu/vcaa/ExcusedAbsence.html
http://www.d.umn.edu/vcaa/ClassNotesAppropriateUseof.html
This syllabus may be amended from time-to-time at the discretion of the instructor.

Homework Requirements

> There is a peculiar synergy between mathematics and ordinary language... The two modes of discourse (words and symbols) stimulate and reinforce one another. Without adequate verbal support, the formulas and diagrams tend to lose their meaning; without formulas and diagrams, the words and phrases refuse to take on new meanings.
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> — David Layzer
>
> (Quoted in Am. J. Phys. **71**, 1223 (2003).)

Homework must be presented in a format so another person can understand the logic and the individual steps of the solution. The solution must be presented in a systematic, step-by-step fashion, with brief explanations of what is being done and the reasoning involved. (Yes, that means using words and learning to write/speak physics!) The presentation must be organized. You may find it necessary to work problems out initially on scratch paper, then re-copy them so the presentation follows a logical flow easily understood by others, with the wrong turns and preliminary mistakes removed.

- Your solution should make clear what the problem is asking. It shouldn't be necessary to consult the problem statement to figure out what problem is being solved.
- Include diagrams that illustrate the system under consideration and identify important variables or parameters in the problem to your diagram. Visualizing the problem whenever possible is a useful habit.
- Start with *basic* principles, definitions, and properties.
- Write complete equations; equations have expressions on both sides of an equals sign. Work *down* the page, presenting one step of a calculation at a time. Don't present several steps in a horizontal sequence, or try to combine several algebraic manipulations into a single line. Neither $\longrightarrow$ nor $\Longrightarrow$ is a substitute for $=$. There's no shame in writing out a series of simple steps in detail to ensure you get the correct result. Hasty work is error-prone.
- Learn and use standard notation. Vector quantities need arrows: $\vec{E}$, $\vec{B}$. Get familiar with and practice the Greek alphabet. For example, density is often denoted by the Greek letter ρ (rho); p is not a suitable substitute for it. Your ρ's shouldn't look like p's. Deliberate practice helps.
- Work problems symbolically as far as possible. Plug in numbers *after* all the algebraic manipulations. When finally plugging in numbers, include units with all numerical values. Show explicitly how the units reduce to the final result as part of the step-by-step presentation. Do not add units at the end of a problem as an afterthought.
- Do not attempt to crowd several problems solutions onto one page. Start a problem on a fresh page. Do not erase large tracts of errant calculations and write over the used real estate. Big mistakes call for a new sheet of paper.
- Don't expect to solve problems adequately in the last hour before class. Start early so you can ask questions in time to get help. The instructor may growl but has never actually bitten a student.

These problem-solving habits can become routine and natural once you make the conscious effort to practice them in every problem.