"Before I came here I was confused about this subject. Having listened to your lecture I am still confused. But on a higher level."

- E. Fermi

Physics 24
Syllabus

Spring Semester 2021

Instructors (Zoom): Jessica Arlett (Section 6): zoom.us/my/arlett
Nicholas Breznay (Section 2 & 7): zoom.us/my/breznay
Elizabeth Connolly (Section 3 & 8): zoom.us/my/prof.connolly
James Eckert (Sections 4 & 9): (by appointment - eckert.ph24@gmail.com)
Mark Ilton (Sections 1, 5 & 10): zoom.us/my/ilton

Group Problems: Tuesdays and Thursdays at 9:35am Pacific

Recitation Sections: Mondays and Wednesdays at 7:00, 10:00 and 11:00am Pacific

Texts: *Motion I and Motion II* by Thomas M. Helliwell, 2013 edition
(accessible at https://edge.edx.org/courses/HarveyMuddX/PHYS024x/2015_Spring/)

Course Sakai site: https://sakai.claremont.edu/portal/site/CX_mtg_HMC_Phys24_SP21

Mission Statement: Harvey Mudd College seeks to educate engineers, scientists, and mathematicians well versed in all of these areas and in the humanities and social sciences so that they may assume leadership in their fields with a clear understanding of the impact of their work on society.

Course Goals and Student Learning: The purpose of this course is to provide you with a thorough introductory background in the principles and applications of classical mechanics. To this end, the course emphasizes problem-solving methods and physical reasoning, as well as the principles of mechanics. These components are presented in complementary ways through asynchronous lecture, recitation, and group-work meetings. In addition to the technical content of the course, we also emphasize the importance of effective oral and written communication in recitation exercises, and the impact of physical reasoning and critical thinking on important issues for society and civilization.

The number of equations in a mechanics course like this is very large, but the number of fundamental concepts is actually rather small. In studying special relativity, you gained insight into the way a physicist approaches knowledge: starting from a small number of observations and definitions, and using logic and mathematics to eke out predictions for specific situations. It is your task to carry that approach forward in this course. Your strategy should not be to memorize every formula derived for the variety of systems we investigate. Rather, **students should aim to understand the chain of reasoning from first principles** used to derive these formulas so that you can apply similar reasoning to analyze new systems. Your work will be evaluated for the clarity and soundness of the reasoning you set forth in course assignments.

Course Structure: Each week, to optimize learning by providing the opportunities for engagement with the material, collaborative problem-solving, and individual assessment, students will participate four components of course activity: (1) asynchronous lectures, (2) synchronous recitations, (3) synchronous small-group problem-solving sessions, and (4) individual end-of-week assessment. These elements have been selected to introduce new material (asynchronous lectures and recitation activities), provide several opportunities for engagement (M/W recitation and Tu/Th classwork problems), and ensure timely low-stakes feedback (end of week solo problems).

1. **Asynchronous Lecture Content:** The course Sakai site has embedded video lectures, notes, miniquestions, and additional resources for each week. A brief numerical, conceptual, or survey

"Miniquestion" on the Sakai site accompanies each set of lecture material. Viewing the lectures and completing these Miniquestions are one component of the final course score. Students should complete these Miniquestions *by 7am on Monday morning each week*, unless otherwise noted.

2. **Recitation Sections:** Recitation sections are Mondays and Wednesdays at 7, 10, and 11am (Pacific). Section meetings will occur via *Zoom* (see "Zoom Links" on Sakai) hosted by your section instructor. Meetings will include opportunities for recaps of the material, Q&A, review, and/or small-group work on problems. *Since recitation section meetings are the most important way for you to work with and receive feedback from your instructor, participation counts for 10% of the final course score.* Please alert your section instructor by email ahead of any absences, whether for conflicts or illness.
3. **Tuesday/Thursday Classwork Group Problems:** During the "lecture" time (Tu/Th, 9:35-10:50am Pacific), you will work in small groups on "classwork group problems". This replaces some of the weekly homework, and provides a dedicated space to work *collaboratively* with your peers on assignments. One person per group will submit your writeup on Gradescope using the "group submission" feature. **Six sets** (i.e. three weeks' worth of assignments) will be dropped so as to maximize your final group problem score.
4. **Solo Homework Problems:** Solving problems helps you master the concepts and methods of the course; the most challenging part of most problems is the setup: figuring out what is being asked and determining what principle(s) to apply. On examinations you will be required to do this on your own; to ensure that everyone gets practice in these steps, *two problems each week are to be completed independently, without consulting other students (including grutors), your course notes, professors, or any other sources.* All solo problems will be submitted and graded using Gradescope, available via the course Sakai site. Solo homework problems are due at *7am Monday morning each week*, unless otherwise noted. Late solo problems will not be graded without your recitation instructor's advance permission. **Six problems** (i.e. three weeks' worth of assignments) will be dropped so as to maximize your final solo problem score.

Problem Solutions and Grading: Problem solutions will be available online, at the course Sakai site. *Solution keys are for post-assignment study only. They may not be reproduced or republished in any form, nor used on pending assignments.* Copying others' work or working from any written, printed or electronic solution, whether that of another student or from archives *is prohibited and will be considered an Honor Code violation*. All graded problems are worth 5 points each. A solution that is entirely correct and adheres to the above guidelines will receive 5 points. Solutions with incorrect physics, algebraic mistakes, or stylistic shortcomings will receive less than full credit, down to a minimum of zero points:

- A complete, correct, and sense-checked solution — 5 points
- Mistakes in the physics and algebra — 1-4 points off
- An inadequate statement of the problem — 1 point off
- Missing diagram(s), where appropriate — 1 point off
- Failure to work symbolically, where appropriate — 1 point off
- Failure to use units, where necessary — 1 point off
- Failure to justify your work using words — 1 point off
- Obtaining a dimensionally inconsistent result — 1 point off

Grading policy: Course grades will be based on

- Exams (60%):
    - Midterm exam (20%),
    - Final exam (30%)
    - Best of midterm and final (10%),

- Solo Problems (10%)
- Participation in recitation section (10%)
- Asynchronous lecture miniquestions (10%) [based on a good-faith effort, not correctness]
- Classwork Group Problems - (10%) [based on a good-faith effort, not correctness]

Piazza Forum: We will use the Ph24 Piazza forum https://piazza.com/hmc/spring2021/phys24 (also linked from the course Sakai site) to allow for questions, discussion, and professor responses. You are encouraged to post conceptual questions after viewing online lectures or working on recitation or example problems!

Other Online Course Resources: An instructor office hours calendar is linked from the side menu "Office Hours" on Sakai. In addition, Academic Excellence and grutor times will appear on the office hours calendar.

Additional resources: First and foremost, see your recitation instructor or another instructor in this course. One of the reasons for coming to Harvey Mudd College is to profit from close interactions with real-live, honest-to-goodness faculty members. Your transition from high school to college made you a member of a community of scholars, formed to construct and share knowledge together. The material in Physics 24 is substantial enough to deserve serious contemplation by both the course instructors and students alike. Please give us the chance to work with you and get to know your scientific thinking.

We are fortunate enough to have two groups of students also supporting this course. Announcements will be made on Sakai and via email concerning the Physics 24 Academic Excellence program. In addition to the AE tutors, we have graders and grutors for each recitation section of the course. Grutors will grade coursework and give feedback on your problem solving. They will also hold grutoring hours during which they are available to answer your questions and help you with extra practice on particular skills.

Resources including the textbook, 2014 lectures, extra problems, overviews, and summaries are available at the course's electronic site: https://edge.edx.org/courses/HarveyMuddX/PHYS024x/2015_Spring/. The lectures and homework sets on the electronic site are different from those associated with this year's course; they are an additional resource, not an alternate way of completing this year's course.

Wellness: The Physics 24 instructors urge you not to attend class when you are ill; please let us know in advance of a missed class if possible, or as soon as you can after the fact. We also know that a variety of events in life can take priority over individual class meetings. Posted materials and the 6 dropped Group Problems are designed to respect those circumstances, which take place from time to time. If an event in your life, public or private, is creating conflicts with class beyond what can already be dealt with in the framework we have set up, please feel free to discuss it with a course instructor.

Belonging: Everyone who is registered for this course belongs here and has valuable contributions to make to our class. Our diversity of backgrounds, experiences, and viewpoints will enrich the classroom, and our mutual respect will grant us all the grace to make mistakes and learn from them.

Academic accommodations: HMC is committed to providing an inclusive learning environment and support for all students. Given our current online learning environment, we recognize that the challenges facing students are different and student accommodation needs may change. Students with a disability (including mental health, chronic or temporary medical conditions) who may need some accommodation in order to fully participate in this class are encouraged to contact Educational Accessibility Services at ability@g.hmc.edu to request accommodations. Students from the other Claremont Colleges should contact their home college's disability resources officer.

Schedule

Note: the problem numbers listed here correspond to the 2013 edition of *Motion I* and *Motion II*. Many problems have different numbers in this edition than in editions prior to 2012. Beware! For your convenience, you may download a PDF or the LaTeX source of the problems from *Motion I* and *Motion II* at https://physics.hmc.edu/motion/.

Note: all times listed are (US) Pacific Time.

Week 1 - Vectors, Kinematics, and Circular Motion

M	1/25	Recitation #1	*Introductions, course logistics*
Tu	1/21	Group #1	
W	1/22	Recitation #2	Week 1 Content and Miniquestions due 7am.
Th	1/23	Group #2	

Week 2 - Newton's laws, center-of-mass, conservation of momentum

M	2/1	Group #3	Week 1 Solo problems & Week 2 Content and Miniquestions due 7am.
Tu	2/2	Lecture #3	
W	2/3	Group #4	
Th	2/4	Lecture #4	

Week 3 - Isolation diagrams, contact forces, gravity; springs, rods, and ropes; internal forces

M	2/8	Recitation #5	Week 2 Solo problems due & Week 3 Content and Miniquestions due 7am.
Tu	2/9	Group #5	
W	2/10	Recitation #6	
Th	2/11	Group #6	

Week 4 - Friction and drag

M	2/15	Recitation #7	Week 3 Solo problems & Week 4 Content and Miniquestions due 7am.
Tu	2/16	Group #7	
W	2/17	Recitation #8	
Th	2/18	Group #8	

Week 5 - Conservation of energy, potential energy, kinetic energy, work

M	2/22	Recitation #9	Week 4 Solo problems due. Week 5 Content and Miniquestions due.
Tu	2/23	Group #9	
W	2/24	Recitation #10	
Th	2/25	Group #10	

Week 6 - Work-energy theorem, elastic and inelastic collisions

M	3/1	Recitation #11	Week 5 Solo problems & Week 6 Content and Miniquestions due 7am.
T	3/2	Group #10	
W	3/3	Recitation #12	
Th	3/4	Group #11	
F	3/5		Week 6 Solo problems due Friday at 5pm.

Spring Break

Week 7 - Review, Midterm Exam

M	3/15	Recitation #13	No material due.
Tu	3/16	Group #12	Review problems
W	3/17	Recitation #14	Midterm 1 released
Th	3/18		
F	3/19		Midterm 1 due at 5pm

Week 8 - Angular Momentum and Torque

M	3/22	Recitation #15	Week 8 Content and Miniquestions due 7am.
Tu	3/23	Group #13	
W	3/24	Recitation #16	
Th	3/25	Group #14	

Week 9 - Rotation of a Wheel; Rotational Energy

M	3/29	Recitation #17	Week 8 Solo problems & Week 9 Content and Miniquestions due 7am.
Tu	3/30	Group #15	
W	3/31	Recitation #18	
Th	4/1	Group #16	

Week 10 - Rotational Vectors; Spin and Orbital Angular Momentum

M	4/5	Recitation #19	Week 9 Solo problems & Week 10 Content and Miniquestions due 7am.
Tu	4/6	Group #17	
W	4/7	Recitation #20	
Th	4/8	Group #18	

Week 11 - Summary of Conservation Laws; Gyroscopes

M	4/12	Recitation #21	Week 10 Solo problems & Week 11 Content and Miniquestions due 7am.
Tu	4/13	Group #19	
W	4/14	Recitation #22	
Th	4/15		No class meeting today.

Week 12 - Simple Harmonic Motion; Oscillating Systems

M	4/19	Recitation #23	Week 11 Solo problems & Week 12 Content and Miniquestions due 7am.
Tu	4/20	Group #21	
W	4/21	Recitation #24	
Th	4/22	Group #23	

Week 13 - Waves on a Rope; Sound, Seismic, Water Waves

M	4/26	Recitation #25	Week 12 Solo problems & Week 13 Content and Miniquestions due 7am.
Tu	4/27	Group #24	
W	4/28	Recitation #26	
Th	4/29	Group #25	
F	4/30		

Week 14 - Wave Superposition; Review

M	5/3	Recitation #27	Week 13 Solo problems & Week 14 Content and Miniquestions due 7am.
Tu	5/4	Lecture	
W	5/5	Recitation #28	

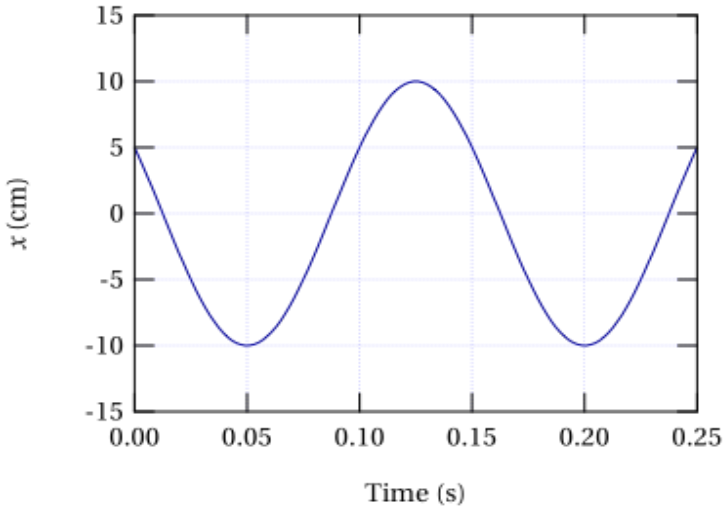
Th 5/6 TBD

Finals Week

M 5/10 **Synchronous Final Exam, 2-5pm**

Supplemental problems

21SUP1 (10 points) A spring with one end fixed at the wall is connected to a block of mass m = 0.050 kg.



The whole system is placed on a frictionless table. The motion of the mass can be described as $x = A\cos(\omega t + \phi_o)$, shown below.

Find (a) the period T, (b) the amplitude A, (c) the initial phase ϕ_o, (d) the force constant k of the spring, (e) the phase of the motion at t = 0.45 s, (f) the displacement at t = 0.45 s. (g) What fraction of the oscillator's energy is the kinetic energy at t = 0.45 s? (h) If instead the motion of the mass is expressed as $x(t) = B\cos(\omega t) + C\sin(\omega t)$, find the constants B and C in terms of given parameters.