

Syllabus for Physics 1230 in Fall 2022

This course completes the introductory physics program by presenting three topics, each taking about 4-5 weeks, in this order in Fall 2022:

1. **Special relativity:** Einstein proposed that the speed of light is the same in any reference frame, the startling consequences include time dilation, length contraction, and paradoxes. Four-vectors in space-time and energy-momentum. Relativistic kinematics for particle collisions and particle decays. Minkowski diagrams. Preparation for general relativity PHYS 5503 introduction to particle physics PHYS 5522. I'll bring in some applications from my research area of experimental particle physics with the ATLAS detector at the CERN LHC.
2. **Thermal physics:** First and second laws of thermodynamics. Ideal gas. Heat transport with conduction, convection, radiation. Heat engines, heat pumps, refrigerators. Entropy. Climate models. Thermodynamics is central to the Industrial Revolution and its consequences for climate change in the 21st century. Preparation for thermodynamics PHYS 4401 "Thermodynamics and the Introduction to Statistical Mechanics and Kinetic Theory".
3. **Vibrations and Waves:** Damped and forced vibrations. Coupled oscillators. Wave equation. Mechanical waves. Electromagnetic waves. Refraction. Interference. Diffraction. Vibrations & Waves describes everything from piano strings to ocean waves to gravitational wave detectors, the applications go on and on. Wave description is fundamental for PHYS 2250 and many advanced physics courses.

Prerequisites: PHYS150/151 or PHYS170/171. It is possible to take 151 in parallel if catching up. MATH 104, and MATH 114 or 116.
Partial derivatives will be needed for thermodynamics (1 month after start of semester).

Corequisite: MATH 240 is encouraged.

(New numbers)

Prerequisites: PHYS0150/0151 or PHYS0170/0171. It is possible to take 0151 in parallel if catching up. MATH 1400, and MATH 1410 or 1610.
Partial derivatives will be needed for thermodynamics (1 month after start of semester).

Corequisite: MATH 2400 is encouraged.

LECTURES: Note well that I have developed a structured, analytical method for my teaching. I try to strike a balance between the introduction of new material with simple examples, and with more difficult examples in a later lecture. The simple examples give students time to interpret the new material and link it to their previous knowledge. Then, in a later lecture, I can help students achieve a deeper understanding of the material and teach critical thinking skills: how to extend ideas to new situations, how to analyze a complicated problem by breaking it down into simpler parts, and how to evaluate whether an answer makes sense or not. You may not find this initially as satisfying as one-lecture-one-topic, however spacing of material between lectures has been shown to improve long-term retention and understanding of concepts, e.g., read "How We Learn", Benedict Carey.

EVALUATION: Weekly reading assignment quiz, weekly active learning, two midterms (1 hour) and a final exam (2 hours).

Each midterm exam is worth 20%. The final exam is worth 30% and will include 1 question each on special relativity and thermodynamics.

(20%) Weekly reading assignment quiz on Canvas. The lowest quiz will be dropped. About half of the quiz will be conceptual questions, the other half will be a similar problem to those on the previous week's homework (your fully worked solution should be uploaded as a pdf file on Canvas). Late submission penalty of 25%. You are encouraged to work with a small group of students on homework assignments and quizzes. The intent here is to help you keep up a steady pace of learning during the semester. Plagiarism alert: please note the names of any students you worked with on the quiz.

(10%) Participation in small groups. The purpose is to try to build some relationships between the students in the class, e.g., talking about special relativity with fellow students should be a lot of fun and a highlight of university physics! Ideally, these small groups could meet to study together outside of the assigned weekly meeting, e.g., to work on homework assignments together. A small group doesn't work if you don't show up, so the grade here will be for regular attendance, which will be checked.

TEXTBOOKS. Four required textbooks, three of which are available at no cost to students.

1. [Special Relativity](#), Helliwell, University Science Books (2009). ISBN-10: 1891389610
2. [Concepts in Thermal Physics](#), 2nd edition, Stephen J. Blundell and Katherine M. Blundell (2009). ISBN-10: 0199562105. [Available online in Penn library at no cost to Penn students.](#) We use parts of this concise textbook, more advanced chapters will be interesting for students taking Statistical Mechanics in future.
3. **Heat and Thermodynamics**, 7th Edition, Zemansky and Dittman, McGraw-Hill (1997). [Free PDF copy](#) will be found on the Canvas site since this book is out of print. ISBN-10: 1138479713. Extremely thorough approach complements Blundell & Blundell.
4. [Vibrations and Waves](#), French, MIT Introductory Physics Series, Chapman & Hall (1971). A classic text, with thoughtful explanations of the theory. [Available online in Penn library at no cost to Penn students.](#)

Other texts:

To achieve a clearer and deeper understanding of a topic, it can be very helpful to read a different view of the same subject. You are not required to purchase these books, but you may find the textbooks below helpful:

- [University Physics](#) Volume 1 (chapters 15-20) and Volume 2 (chapters 35-37), Young & Freedman, Pearson are useful for a brief introduction to waves and thermodynamics. Any recent edition is fine. This is the main textbook for PHYS150/151 so widely available on campus, and copies available in the Math & Physics library.
- [Special Relativity](#), French, MIT Introductory Physics Series, Chapman & Hall. A classic text. [Available online in the Penn library at no cost to Penn students.](#)
- [E=mc²: a biography of the world's most famous equation](#), David Bodanis. An easy-to-read book with the history and background.

- [Introduction to Mechanics](#), Kleppner & Kolenkow, Cambridge University Press. A rather forbidding text, see the chapters on Relativistic Energy and Momentum.
- [Oscillations and Waves: an introduction](#), 2nd Edition, Richard Fitzpatrick, (2018), ISBN-10: 1138479713. A concise approach with examples.

OFFICE HOURS: Office hours will be held each week in person.

WEEKLY READING ASSIGNMENTS

Special Relativity (first midterm topic and 1 question on final)		
Week 1	Time dilation, length contraction	HE 1-5
Week 2+3	Simultaneity, Paradoxes, Lorentz Transformations	HE 6-9
Week 4	Energy & Momentum	HE 10-13
Thermodynamics (second midterm topic and 1 question on final)		
Week 1	Temperature and Heat Transfer, heat capacity	UP 17 and BL 1-4
Week 2	Ideal gas, kinetic theory, work	UP 18 and BL 5-6 ZE 3.1-3.5, 5.1-5.6
Week 3	First law of thermodynamics	UP 19 and BL 11-12 ZE 4.1-4.10
Week 4	Second law of thermodynamics	UP 20 and BL 13 ZE 6.1-6.14, ZE 7.1-7.7,
Week 5	Entropy	BL 14 ZE 8.1-8.14
Vibrations & Waves (final exam topic)		
Week 1	Damped and Driven Harmonic Oscillations	FI 1-2 French
Week 2	Coupled Oscillators	FI 3 French
Week 3	Standing Waves	FI 4-5 French UP 15-16
Week 4	Traveling Waves	FI 6 French UP 15-16
Week 5+6	Interference & Diffraction	FI 10 French UP 35-36

HE= Helliwell

UP = University Physics (rent from Bookstore)

BL = Blundell (free online through library)

ZE = Zemansky (free PDF on Canvas)

French (free online through library)

FI = Fitzpatrick