Physics 434/534 – Thermal Physics Spring 2026
Syllabus

- **Instructor:** Antonio Cancio
  - office: CS 439
  - office hours: M 1:00 PM, Tu 3 PM, W 10 AM, Th 10 AM, TBD
  - phone: 285-8868
  - email: accancio@bsu.edu (response in 24 hours)
- **Text:** Schroeder, *Introduction to Thermal Physics*, 10th ed., Oxford University Press.
- **Class Hours:** Monday, Wednesday, Friday, 3:00-3:50, CS 311
- **Prerequisites:** Maths 166, Phycs 330.
- **Outline and Rationale:** The course follows two halves, between which we will switch several times during the semester. The first half deals with thermodynamics, a great phenomenological structure developed to describe the nature of heat and thermal processes from a self-consistent macroscopic viewpoint. The second half is statistical mechanics, the model built by Boltzman and others to derive the laws of thermodynamics from the atomistic point of view. A good part of the course is to learn how theories are constructed, starting from the systematic observation of nature and ending up with detailed and predictive pictures of the large part of the universe we can't observe directly.
- **Objectives:** As a result of completing this course, the graduate student will demonstrate an ability to
  - Know and apply the basic principles of thermodynamic transformations through work and heat.
  - Apply basic statistical properties of large numbers to predict behavior of random processes such as Brownian motion.
  - Identify the statistical foundations of entropy and how it is used to generate thermodynamic relations via conditions of thermal, mechanical and chemical equilibrium.
  - Identify the laws of thermodynamics and apply them to analyze the properties and design of heat engines and refrigerators.
  - Describe free energy and use it to analyze and predict chemical thermodynamic phenomena including phase transitions.
  - Use the Boltzman distribution to calculate basic statistical properties of quantum systems.

- Apply the techniques of statistical mechanics to quantum distributions of particles obeying fermionic and bosonic statistics, and predict basic properties of solids, blackbody radiation and thermal noise.

- **Course Structure:** Classes will meet for lecture three times a week, with occasional activities and quizzes. There will be weekly homework assignments, three hour exams and a final. One of the hour exams will be take-home, one may be held in the evening, schedules' permitting. There is no lab component to the course.

- **Reading:** In upper level classes, you should begin the practice of depending on more than one textbook. Other books have insights the "official" one doesn't, as well as additional problems solutions, and examples. A bibliography of useful references, some on reserve in the library, is included below.

- **Assignments:** Working out homework problems is in most upper-level physics courses a key to really learning the subject. This will give you the opportunity to grapple and become comfortable with the theoretical concepts and methods we will encounter. I hope you will find the homework to be challenging, occasionally memorably so, but ultimately rewarding you with a deeper insight into the physical world. I will assign homework roughly once every week, and will grade the problems assigned. You will learn most effectively by working as much out as you can on your own – but discussing and working with each other will not be frowned upon.

  In doing assignments, any resource reasonably available to you in your career as a researcher is "fair game". This includes textbooks, web resources, mathematics software, discussions with your professor, and especially discussions with each other. This does not include publicly available solutions to homework problems. Please refrain from consulting such until *after* assignments are due. You will learn most effectively by working as much out as you can on your own, but in general you will not be able to do everything yourself – the key is to find the right balance.

  Late homework will be penalized up to 50%. Work will not be accepted once I have returned assignments.

  Bonus homework will occasionally be offered and accepted, with a maximum homework grade from bonus of 110%.

  Graduate Assignment: Additional for graduate-level students – each week, in addition to the assigned problem set, you should seek out on your own an additional problem to solve, from Schroeder, another textbook or other source. At least one of these problems must be adapted from a journal article. Problems will be weighted as follows – 5-15 points for textbook problem with solution, depending on the difficulty, 20 points for journal articles or other major task. These will add up to a total possible 100 points.

- **Examinations:** Three midterms and one final will be given. These will mostly consist of worked out problems but some discussion questions may be given. Know your introductory level physics – it is a good source for exam questions. Exam questions will be drawn from the topics discussed since the last exam, but will build upon ideas and concepts from all material previously covered. **Make up** exams will be given only for circumstances deemed valid by the instructor. Please give notice that you will miss an exam as soon as possible, preferably **before** the exam.

- **Grading:** Final grades will be determined using the following weighting:

  Homework/Activities: 30% Midterms: 45% Final: 25%

  Numerical grades correspond to letter grades as follows:

90.0-100:	A	86.7-90.0:	A^-	83.3-86.7:	B^+	80.0-83.3:	B
76.7-80.0:	B^-	73.3-76.7:	C^+	70.0-73.3:	C	66.7-70.0:	C^-
56.7-66.7:	D	0.0-56.7:	F				

- **Miscellany**

  Attendance in class is not required, but is expected. Regular attendance in class, participation in class discussions and activities, completion of assignments will be considered in assignment of final grades.

  Cheating or other forms of **Academic Honesty** is prohibited at Ball State University. Although you are encouraged to work together on labs and other assignments your final report or homework must be your own. Copying other peoples work or using AI without attribution is not permitted and may be subject to disciplinary measures.

  All work conducted and/or submitted in this course must be your own, completed in accordance with the Ball State University's Student Academic Ethics Policy. You may not normally collaborate with or make use of ChatGPT or any other **generative AI** applications to develop materials submitted in this course. Exceptions will be made on a case-by-case basis, and guidelines will be given for attribution. Trivial AI tools like autocomplete features in an editor are allowed.

  Disclaimer: This syllabus is subject to change in the event of extenuating circumstances.

- **University Policies**

  We are committed to ensuring that all **members of the community are welcome**, through valuing the various experiences and worldviews represented at Ball State and among those we serve. We promote a culture of respect and civil discourse.

  In this course, we are committed to fostering a learning environment that values **intellectual diversity**, encourages free expression, and promotes open inquiry. As members of the Ball State Community, we treat each person in the Ball State community

with civility, courtesy, compassion, and dignity and respect and learn from differences in people, ideas, and opinions. Please review Ball State University's Statement on Freedom of Expression, the resources on Ball State's Freedom of Expression webpage, and Ball State's Beneficence Pledge.

If you need course **adaptations or accommodations** because of a disability, or if you have emergency medical information to share with me, please contact me as soon as possible. Ball State's Disability Services Office coordinates services for students with disabilities; documentation of a disability needs to be on file in that office before any accommodations can be provided. Disability Services can be contacted at 765-285-5293 or dsd@bsu.edu.

- **Bibliography:**
  - *Thermal Physics*, Ralph Baierlein (Cambridge University Press 1999). A good modern text on statistical mechanics with some recent applications like Bose-Einstein condensation
  - *Thermal Physics*, Kittel and Kroemer, 2nd ed. (W. H. Freeman, 1980). Classic reference for statistical mechanics.
  - *Modern Thermodynamics* Kondepudi and Prigogine (Wiley, 1998) Good text on thermodynamice, especially its extension to nonequilibrium systems, an important area of modern research.
  - *Thermodynamics, Kinetic Theory and Statistical Thermodynamics*, Sears and Salinger, 3rd ed. (Addison Wesley, 1975). Classic reference for classical thermodynamics.

Tentative Schedule of Reading and Assignments for Physics 434/534 Thermodynamics, Spring 2004

Week of	Reading	Topics	Assigments
Jan 5	Chap 1	Basics: temperature and kinetics	
Jan 12	Chap 1	Basics: energy and thermodynamic processes	
Jan 19	Chap 1	Basics: thermodynamics, thermal transport	
Jan 26	Chap 2	Entropy: statistical point of view	
		Exam I, Feb 2	
Feb 2	Chap 2	Entropy II	
Feb 9	Chap 3	Microcanonical Ensemble	
Feb 16	Chap 3	Microcanonical Ensemble	
Feb 23	Chap 4	Heat Engines I	
Mar 2		**Spring Break**	
		Exam II, Feb 27 (Take Home?)	
Mar 9	Chap 4	Heat Engines II	
Mar 16	Chap 5	Applications of Thermodynamics II	
Mar 23	Chap 5	Applications of Thermodynamics II	
Mar 30	Chap 5	Applications of Thermodynamics III	
		Exam III, TBA, Apr 6-10 (Evening?)	
Apr 6	Chap 6	Boltzman Statistics	
Apr 13	Chap 6 and 7	Quantum Statistics	
Apr 20	Chap 7	Bose and Fermi Gases	
Apr 27	NA	Review	

Final Exam, comprehensive, 2:15 PM, Wednesday, April 29

Class will not be held Jan 19, Mar 2-6 and TBA, week of Feb 23 and Mar 16