PHYS 330: Thermal & Statistical Physics

Term: Fall 2026
Credits: 3.0
Lecture Times & Location: Tuesday & Thursday 4:00–5:15 p.m., Meridian Science Center 120
Modality: In-Person

Instructor Information

- **Instructor:** Dr. Chidi Okoro (Associate Professor of Physics)
- **Email:** cokoro@university.alkimi.ai
- **Office:** Meridian Science Center 412
- **Office Hours:**
  - Monday & Thursday: 1:00–2:30 p.m. (In person, Meridian Science Center 412)
  - Wednesday: 2:00–3:00 p.m. (Virtual via Zoom; link posted in Canvas)
  - Also available by appointment.

Course Description

Laws of thermodynamics, entropy, free energies, kinetic theory, the Boltzmann distribution, partition functions, and quantum statistics with applications to gases, solids, and radiation. PHYS 330 synthesizes classical macroscopic thermodynamics with microscopic statistical mechanics to explain the thermal behavior of physical systems. Beginning with temperature, heat capacities, and the fundamental laws of thermodynamics, we explore thermodynamic potentials, Legendre transforms, and phase equilibria. We then transition to the statistical foundation of entropy, deriving the microcanonical, canonical, and grand canonical ensembles, Boltzmann and Gibbs distributions, partition functions, and quantum statistics for ideal Bose and Fermi gases.

Prerequisites

PHYS 221 and MATH 240.

Measurable Student Learning Outcomes

Upon successful completion of PHYS 330, students will be able to:

1. **Apply the Laws of Thermodynamics:** Calculate work, heat, internal energy, entropy changes, and maximum efficiencies for diverse thermodynamic cycles and processes.
2. **Utilize Thermodynamic Potentials and Maxwell Relations:** Formulate enthalpy, Helmholtz free energy, and Gibbs free energy, and apply Maxwell relations to derive relationships between measurable thermal quantities.
3. **Connect Microscopic Microstates to Macroscopic Entropy:** Compute multiplicity functions for simple quantum systems (two-state paramagnets, Einstein solids) and apply Boltzmann's statistical definition of entropy.

4. **Calculate Partition Functions in the Canonical Ensemble:** Construct single-particle and system partition functions to determine average energies, heat capacities, pressures, and equations of state.
5. **Evaluate Grand Canonical Systems and Chemical Potential:** Apply the grand partition function and chemical potential to open systems, adsorption models, and chemical equilibrium.
6. **Analyze Quantum Statistics: Fermi-Dirac and Bose-Einstein:** Derive Fermi-Dirac and Bose-Einstein distribution functions, analyzing electron degeneracy pressure in metals/white dwarfs, Planck blackbody radiation, and Bose-Einstein condensation.

Required Course Materials & Approximate Costs

1. **Schroeder, Daniel V. *An Introduction to Thermal Physics*. Oxford University Press, 2021.** Approx. $55 for paperback or digital purchase.
2. **Scientific calculator with exponential and logarithmic capabilities.** Approx. $15 to $25.
3. **Total estimated cost:** $55 to $80.

Generative AI Policy (AI Level 2: AI Permitted with Disclosure for Specified Tasks)

In accordance with Alkimi University Academic Policies (Student Handbook §5.8), PHYS 330 operates under **AI Level 2**.

- **What is permitted:** You may use AI tools to visualize thermodynamic phase diagrams, generate practice problems on combinatorics and partition functions, and clarify the physical interpretation of entropy and chemical potential.
- **What is prohibited:** You may not submit AI-generated derivations or problem solutions for weekly assignments, generate computational code for graded projects without acknowledgment, or access any generative AI during examinations.
- **Disclosure:** On each submitted problem set, include a written statement describing which AI tools were consulted and detailing how you confirmed the validity of the statistical derivations, or confirm that no AI tools were used.

Grading Components and Weights

- **Midterm Exam 1:** 20% (In class, Thursday, September 24)
- **Midterm Exam 2:** 20% (In class, Thursday, October 29)
- **Weekly Analytical Problem Sets:** 25% (Due Fridays at 11:59 p.m. in Canvas (weeks 2–13; lowest dropped))
- **Statistical Modeling Project:** 10% (Due Friday, November 20 at 11:59 p.m.)
- **Final Comprehensive Examination:** 25% (Thursday, December 17, 2026, 3:30–5:30 p.m.)

Grading Scale (Alkimi University Standard)

- **A:** 93–100% | **A-:** 90–92%
- **B+:** 87–89% | **B:** 83–86% | **B-:** 80–82%
- **C+:** 77–79% | **C:** 73–76% | **C-:** 70–72%
- **D+:** 67–69% | **D:** 60–66% | **F:** Below 60%
- **Extra credit:** No extra credit assignments are offered in PHYS 330.

Course Schedule (Fall 2026)

Week	Dates	Topics & Readings	Assignments & Deadlines
Week 1	Aug 27	**Thermal Equilibrium and Ideal Gases:** Macroscopic state variables, zeroth law of thermodynamics, temperature scales, ideal gas equation of state, and microscopic model of pressure. *Reading: Schroeder Ch. 1.1–1.3*	*First day of classes: Wed Aug 26.*

Week	Dates	Topics & Readings	Assignments & Deadlines
Week 2	Sep 1, 3	**First Law of Thermodynamics and Heat Capacities:** Quasistatic compression work, heat transfer, internal energy conservation, enthalpy, heat capacities at constant volume and pressure, and adiabatic processes. *Reading: Schroeder Ch. 1.4–1.7*	*Wed Sep 2: Add/section change deadline.*
Week 3	Sep 8, 10	**Microstates, Macrostates, and Multiplicity:** Two-state paramagnet, coin tossing combinatorics, macrostates and accessible microstates, multiplicity functions, and Stirling's approximation. *Reading: Schroeder Ch. 2.1–2.3*	*Mon Sep 7: Labor Day (no classes). Wed Sep 9: Census date (last day to drop without a W).*
Week 4	Sep 15, 17	**The Einstein Solid and Thermal Contact:** Multiplicity of coupled Einstein solids, energy exchange, sharply peaked multiplicity distributions for macroscopic systems, and irreversible thermalization. *Reading: Schroeder Ch. 2.4–2.6*	—
Week 5	Sep 22, 24	**Entropy and the Second Law & Midterm Exam 1:** Boltzmann definition of entropy, statistical formulation of the second law, entropy of an ideal gas (Sackur-Tetrode formula); Midterm Exam 1 in class. *Reading: Schroeder Ch. 3.1–3.3*	**Midterm Exam 1 (in class).**
Week 6	Sep 29, Oct 1	**Temperature, Pressure, and Chemical Potential:** Thermodynamic definition of temperature as entropy derivative, mechanical equilibrium and pressure, diffusive equilibrium and chemical potential. *Reading: Schroeder Ch. 3.4–3.6*	—
Week 7	Oct 6, 8	**Heat Engines, Refrigerators, and Carnot Cycle:** Heat engine cycles, thermal efficiency, Carnot theorem, refrigerators, heat pumps, coefficients of performance, and real engine limitations. *Reading: Schroeder Ch. 4*	—
Week 8	Oct 15	**Free Energies and Thermodynamic Potentials:** Legendre transformations, Helmholtz free energy, Gibbs free energy, maximum available work, and conditions for spontaneous equilibria. *Reading: Schroeder Ch. 5.1–5.3*	*Oct 12–Oct 13: Fall break (no classes).*
Week 9	Oct 20, 22	**Maxwell Relations and Phase Transformations:** Thermodynamic identity, Maxwell relations, Clausius-Clapeyron equation, liquid-gas phase coexistence, and van der Waals fluids. *Reading: Schroeder Ch. 5.4–5.6*	—
Week 10	Oct 27, 29	**The Boltzmann Factor and Canonical Ensemble & Midterm Exam 2:** Thermal reservoir coupling, Boltzmann probability distribution factor, average values, and canonical ensemble formulation; Midterm Exam 2 in class. *Reading: Schroeder Ch. 6.1–6.3*	**Midterm Exam 2 (in class).**
Week 11	Nov 3, 5	**The Partition Function and Equipartition:** System partition function Z, connection between Z and Helmholtz free energy, average energy, rotational and vibrational partition functions of molecules. *Reading: Schroeder Ch. 6.4–6.7*	*Fri Nov 6: Last day to withdraw (W) or elect Pass/No Pass.*
Week 12	Nov 10, 12	**Maxwell-Boltzmann Speed Distribution:** Velocity distribution of gas particles, root-mean-square speed, most probable speed, equipartition theorem proof, and canonical ideal gas. *Reading: Schroeder Ch. 6.8–6.10*	—
Week 13	Nov 17, 19	**Grand Canonical Ensemble and Chemical Equilibrium:** Gibbs factor, grand partition function, grand potential, adsorption isotherms, and chemical reactions in dilute solutions. *Reading: Schroeder Ch. 7.1–7.2*	**Statistical Modeling Project due Fri Nov 20 at 11:59 p.m.**
Week 14	Nov 24	**Quantum Statistics: Identical Particles:** Indistinguishability of particles, symmetric and antisymmetric states, single-particle energy states, and the quantum Gibbs paradox resolution. *Reading: Schroeder Ch. 7.3*	*Nov 25–Nov 27: Thanksgiving break (no classes).*
Week 15	Dec 1, 3	**Fermi-Dirac Statistics and Degenerate Matter:** Fermi-Dirac distribution function, Fermi energy, density of states, electron	—

Week	Dates	Topics & Readings	Assignments & Deadlines
		gas in metals, and white dwarf degeneracy pressure. *Reading: Schroeder Ch. 7.4–7.5*	
Week 16	Dec 8	**Bose-Einstein Statistics, Radiation, and Review:** Bose-Einstein distribution function, Planck blackbody radiation law, photon gases, Bose-Einstein condensation, and comprehensive review. *Reading: Schroeder Ch. 7.6–7.7 & Review*	*Wed Dec 9: Last day of classes. Thu Dec 10: Reading Day.*
Finals	Dec 17	**Final Comprehensive Examination:** Thursday, December 17, 2026, 3:30–5:30 p.m., Meridian Science Center 120.	Comprehensive examination covering macroscopic thermodynamics, statistical ensembles, partition functions, and quantum gases.

Course Policies

Attendance Policy

Because PHYS 330 covers subtle statistical and thermodynamic derivations that require direct interactive dialogue, regular attendance at both weekly Tuesday and Thursday lectures is expected. Notify Dr. Okoro via email in advance of any legitimate excused absence. Missing more than three lectures without excuse may lower your final course grade. Students who miss the first two class meetings without notifying the instructor may be dropped. Students may miss class for religious observance without penalty if they notify the instructor in writing within the first two weeks of the semester (by Wednesday, September 9, 2026). Absences for university-sponsored activities (athletics, performances, conferences) are excused with a letter from the sponsoring office at least one week in advance.

Late Work Policy

Problem sets submitted within 24 hours of the deadline incur a 20% penalty. Because complete solution sets are published 24 hours after the deadline, no submissions can be accepted after that window. The lowest problem set grade is dropped to accommodate unforeseen illnesses.

Final Exam Policy

The final examination (Thursday, December 17, 2026, 3:30–5:30 p.m.) is scheduled by the University Registrar and can't be moved without the Dean's written approval (Faculty Handbook §5.5). A student with three or more final exams on the same calendar day may reschedule one of them. Requests go to the instructor of the middle exam by the last day of classes. For this term, send the request by Wednesday, December 9, 2026 (Student Handbook §6.4).

Academic Integrity

Alkimi University is an academic community devoted to rigorous scholarship, open intellectual inquiry, and uncompromising ethical conduct. All students are subject to the regulations of the Alkimi University Academic Integrity Policy. Academic dishonesty—including plagiarism, cheating on examinations, unauthorized collaboration, fabrication of empirical data, and unauthorized submission of academic work generated by artificial intelligence—undermines the integrity of the university and carries severe disciplinary sanctions. Sanctions range from a failing grade on an assignment or exam to an administrative course failure recorded as an 'XF' on the official transcript, academic suspension, or expulsion. Suspected violations are formally investigated and resolved through the Office of Academic Integrity in accordance with Faculty Handbook §6. For detailed information, consult the Office of Academic Integrity, Lovell Hall 315, (555) 555-0163, integrity@university.alkimi.ai.

Accessibility Services

Alkimi University is committed to providing equitable educational access and reasonable accommodations for all students with documented disabilities, including physical, sensory, psychological, learning, and chronic health conditions. Students requesting academic accommodations must formally register with the Office of Accessibility Services, Harlan Hall 204, (555) 555-0155, access@university.alkimi.ai. Once approved, students will receive an official Faculty Accommodation Letter detailing approved accommodations. Students should present this letter to the instructor as early in the semester as possible, and at least one week prior to any exam or assignment requiring accommodation. Accommodations cannot be applied retroactively.

Student Wellness and Mental Health

Your physical health, psychological well-being, and mental health are essential to your academic success. If you experience heightened stress, anxiety, depressive symptoms, personal trauma, or academic burnout, free, confidential counseling and medical care are available through the Hollis Health & Counseling Center, located in the Hollis Center. Routine appointments are available Monday–Friday 8:00 a.m.–6:00 p.m. and Saturday 10:00 a.m.–2:00 p.m. during the semester by calling (555) 555-0190 or emailing health@university.alkimi.ai. Urgent, 24/7 crisis psychological counseling is accessible immediately at (555) 555-0199.

Campus Student Support Services

- **Academic Advising Center:** Lovell Hall 101 | (555) 555-0158 | advising@university.alkimi.ai
- **Writing Center:** Whitcombe Library 3rd Floor | Free consultations on papers, reports, and research projects at any stage.
- **Whitcombe Library:** Whitcombe Library, Main Floor | (555) 555-0170 | askalibrarian@university.alkimi.ai
- **Hollis Health & Counseling Center:** Hollis Center | (555) 555-0190 | 24/7 Counseling Line: (555) 555-0199 | health@university.alkimi.ai
- **Physics Tutoring Center:** Drop-in peer tutoring and conceptual assistance are available Monday through Thursday from 2:00 to 6:00 p.m.