Syllabus, PHYS 307, Thermal Physics, Spring 2021

Time: 1:30-2:45pm, MW
Place: Online
Instructor: Erhai Zhao
Office Hour: 2:00-3:00 PM, Tuesday (tentative, subject to change upon student request)
Email: ezhao2@gmu.edu

How to reach me
Email is preferred during distance learning. I will try to respond within 24 hours.
I will log into the classroom 10 minutes before, and stay for another 10 minutes (or longer if needed) after each session on BlackBoard Collaborate Ultra (BBCU). Unmute yourself to chat or ask questions.

Textbook
Concepts in Thermal Physics, 2nd Ed, by S. J. Blundell and K. M. Blundell (Oxford). This is the text used at Oxford, I like its approach and style.

Warning: the content or the order of the lectures may deviate from the textbook.

There are many excellent textbooks out there on thermodynamics and statistical mechanics. Previous instructors have used *An Introduction to Thermal Physics,* by D. Schroeder (Addison-Wesley), and *Fundamentals of Statistical and Thermal Physics*, by F. Reif (McGraw-Hill).

Grades
Midterm (25%), final (25%), homework (50%).

Blackboard
We will use Blackboard, available at https://mymason.gmu.edu. Students need to have access to stable broadband Internet connection.

Announcements, lecture notes and other supplementary materials, exams, and homework assignments will be posted on Blackboard. You are responsible for checking it on a regular basis.

Lectures
Lecture will be delivered using OneNote and BBCU's screen sharing function. Some of our synchronous meetings will be recorded so students can review them if necessary. Recordings will be stored on Blackboard and will only be accessible to students enrolled in this course during this semester.

Homework
Weekly homework will be assigned on Blackboard with due date indicated. Solving the homework problems independently is the single most important part of learning (and 50% of your grade). Discussion with peers is encouraged but copying solutions from each other or from solutions, regardless of the source, is a violation of the GMU honor code and leads automatically to zero credit or an F grade.

To submit homework, upload a single pdf file to BB. Bloated, compressed, or multiple image (such as jpg, png, or tiff) files will be returned. In case of BB technical difficulties, email it to me directly.

Each homework will be graded using a coarse scale (0 to 5 out of 5). Late homework will not be accepted unless a written notice with a valid excuse is sent to the instructor before the due date.

Exams
There is one midterm exam covering the first half of the semester. The final exam will cover topics in the second half semester. Most exam problems will be similar to the homework problems in terms of difficulty levels, but some may be a little more difficult. The exams are open-book and open-notes (and

will not be proctored online). You must submit your answer before the due date and time as specified. An honor code statement must be signed together with your answer. Discussion with anyone else, including using online forums or paid services, constitutes an honor code violation and results in an F grade.

Prerequisites
Mature math skills are assumed. You should be comfortable with partial derivatives, multiple integrals, sum and product of series, probability, and statistics. Work through appendix B and C to refresh your memory.

You are also assumed to (1) have a solid grasp of classical mechanics; (2) know the basic ideas of quantum mechanics (energy levels, Planck's constant, uncertainty principle etc., at the level of Young and Freedman, University Physics, chapter 38-41); and (3) have some basic knowledge of thermodynamics (at the level of Young and Freedman, chapter 17-20). Work through these chapters if you have not done so.

Topics (Learning outcomes)

The plan is to cover the fundamentals of thermodynamics and statistical mechanics. We will skip chapters 8-10, 15, 25, 27, 31-37 of the book. Some chapters, e.g. 22-24 and 30, will be condensed.

I. Kinetic theory of gas: thermodynamics and statistical mechanics work together to understand matter
1. Examples of thermodynamic systems, equation of state, ideal gas and spin chain.
2. Large numbers, Stirling formula, macro vs microstates, entropy defined.
3. Thermal equilibrium, zeroth law, thermometer, statistical definition of temperature.
4. Boltzmann distribution, applied to two-state systems.
5. Probability distribution, random variables, standard deviation, binormal and Gaussian distribution.
6. Kinetic theory of gases, Maxwell distribution, Gaussian integrals, effusion.

II. Thermodynamics
7. Internal energy, the first law, heat and heat capacity, isothermal and adiabatic processes.
8. Heat engines, Carnot's theorem, the second law (Kelvin vs Clausius), Clausius theorem/inequality.
9. Thermodynamic entropy, computing the entropy change, reconciliation with Boltzmann's entropy formula, mixing, the third law.
10. Thermodynamic potentials U, H, F, G; natural variables, partial derivatives, Maxwell relations.

Midterm Exam

11. Availability, minimization of free energy.
12. Generalizations: rods, rubber bands, magnets…

III. Statistical mechanics

13. Fundamental postulate. Gibbs entropy and its maximization. Three kinds of Ensembles.
14. Canonical ensembles, partition function. Sausage machine. Two-level system, spin chain again.
15. Ideal gas revisited. Thermal de Broglie wave length. Density of states.
16. Classical stat mech. Harmonic oscillator. Equipartition theorem. Diatomic gas.
17. Grand canonical ensemble, chemical potential. Grand partition function and grand potential.
18. van der Waal gas, liquid-gas transition, critical phenomena.
19. Phase transitions, Clausius-Clapeyron equation, classification of phase transitions, Ising model in 2D.
20. Quantum statistics. Bose and Fermi gases. Photons and phonons.

Final Exam

Time permitting, I will squeeze in some discussion on Transport, Fluctuations, and Linear Response. But they will not appear in homework or exams.

University Resources
Learning Services (https://learningservices.gmu.edu/)
Student Support and Advocacy Center (https://ssac.gmu.edu/)
Counseling and Psychological Services (https://caps.gmu.edu/)
Mason's Title IX Coordinator (703-993-8730, titleix@gmu.edu)

Academic Integrity
The George Mason University Honor Code can be found at the Office of Academic Integrity website http://oai.gmu.edu. It has clear guidelines regarding cheating, plagiarism, and other academic misconduct.

Accommodations
Disability Services at George Mason University is committed to providing equitable access to learning opportunities for all students by upholding the laws that ensure equal treatment of people with disabilities. If you are seeking accommodations for this class, please first visit http://ds.gmu.edu/ for detailed information about the registration process, then discuss your approved accommodations with me. Disability Services is located in Student Union Building I (SUB I), Suite 2500.
Email:ods@gmu.edu; Phone: (703) 993-2474.

Diversity and Inclusion
Please refer to Mason's Non-Discrimination Policy,
https://universitypolicy.gmu.edu/policies/non-discrimination-policy/.
and the Mason Diversity Statement,
https://stearnscenter.gmu.edu/knowledge-center/general-teaching-resources/mason-diversity-statement/.

Course Materials and Student Privacy
All course materials posted on Blackboard are private to this class; by federal law, any materials that identify specific students (via their name, voice, or image) must not be shared with anyone not enrolled in this class. These include live BBCU videos and their recordings made by instructor or students.

Sharing of instructor-created materials, particularly materials relevant to assignments or exams, to public online "study" sites may be considered a violation of Mason's Honor Code. Ask for instructor's permission before distributing lecture notes or homework solutions to anyone not enrolled in this class.