Syllabus, PHYS 307, Thermal Physics, Spring 2022

Time: 1:30-2:45pm, MW
Location: Exploratory Hall L111
In case of switching to virtual instruction: Log in Blackboard, and follow the Zoom Class Meet link.

Instructor: Erhai Zhao
Email: ezhao2@gmu.edu
How to reach me: The best place to ask questions is during or immediately after the class. You can also send me emails, please be mindful that I only check mail a few times during the work day. If a fixed "office hour" (online, via Zoom) is in popular demand, the time will be announced and the meeting link will show up in Blackboard/Zoom Class Meet.

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

There are many other good textbooks 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 (30%), final (30%), homework (40%).

Blackboard
Announcements, course materials, homework assignments, and possibly Zoom meeting links will be posted on Blackboard. You are responsible for checking it on regular basis.

Lectures
Lectures will be delivered in classroom using the white board. Please note the content or order of the lecture will deviate from the textbook. So if you miss a lecture, the best way to make up is to borrow notes from a peer. Projectors will be used to show graphics and animations.

Homework
Homework will be assigned on Blackboard with due date indicated. Solving the homework problems independently is crucial to your success in this class. Discussion with peers is encouraged but copying solutions from each other, or from solutions from any source, is a violation of the GMU honor code and will lead to zero credit or an F grade.

Each homework will be graded using a coarse scale (e.g. 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. Solution to homework problems will be given.

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 those in homework in terms of difficulty levels, but some may be harder. You can bring a self-prepared formula sheet (one sheet of paper, letter sized, both sides may be used) to the exam. No cell phones, laptops, books, or notes are allowed. Solution to exam problems will not be distributed.

Prerequisites
Mature math skills are assumed. You should be familiar with partial derivatives, multiple integrals, sum & product of series, probability and statistics. Work through appendix B and C of the textbook to get an idea of the math level involved.

To get the most out of this course, you are also assumed to have

(1) a solid grasp of classical mechanics (kinetic and potential energy, momentum and collision, rotations, harmonic oscillators, waves…);

(2) basic ideas of quantum mechanics (energy levels, Planck's constant, quantum numbers etc., at the level of Young and Freedman, University Physics, chapter 38-41);

(3) basic knowledge of thermodynamics, at the level of PHYS 266, Introduction to Thermodynamics (e.g. Young and Freedman, chapter 17-20).

Topics [subject to change]

Our plan is to cover the essentials of statistical mechanics and thermodynamics. We will skip chapter 10, 25, 27, 31-37 of the book. Some chapters, e.g. 8-9, 15, 22-24 and 30, will be condensed.

I. Kinetic theory of gas

1. 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, transport.

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: bubbles, 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]

Safety

All students taking courses with a face-to-face component are required to follow the university's public health and safety precautions and procedures outlined on the university Safe Return to Campus webpage (https://www2.gmu.edu/safe-return-campus). Students are required to follow Mason's current policy about facemask-wearing. An appropriate facemask must cover your nose and mouth at all times in our classroom. If this policy changes, you will be informed; however, students who prefer to wear masks either temporarily or consistently will always be welcome in the classroom.

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.

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. Always ask for instructor's permission before distributing lecture notes or homework solutions to anyone not enrolled in this class.

Academic Integrity
The George Mason University Honor Code can be found at the Office of Academic Integrity website http://oai.gmu.edu. It contains 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/.

More 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)