Statistical mechanics

Physics 807

Catalog description: Review of thermodynamics. Classical statistical mechanics and applications. The virial expansion. Quantum statistical mechanics and the micro-canonical, canonical, and grand-canonical ensembles. The Fermi and Bose gases, and applications. Special topics in statistical mechanics.

Prerequisites: This course requires knowledge of quantum mechanics and basic college math, including complex functions, matrices, linear algebra, the Fourier transform and simple linear differential equations

University Catalog	PHYS 807. Statistical mechanics. 3 Credit.
Classes	Tuesdays and Thursdays: 11:00 – 12:15 Physical Sciences II, room 2108
Instructor	Dr. Alexander Godunov Office: OCNPS 219 (Oceanography and Physics) Phone: 683-5805 agodunov@odu.edu Web: www.odu.edu/~agodunov
Textbooks	*Statistical Mechanics by* K. Pathria and P.D. Beale, 3rd Edition, Elsevier, 2011 (main textbook) *Statistical mechanics* by R. Feynman, Benjamin, 1972 (optional)
Support resources	*Office hours*: Tuesday 13:30-14:30 in OCNPS 219, Thursday 10:00-11:00 in OCNPS 219 and by appointment. Canvas: Lecture notes and potentially some video lectures *E-mail*: agodunov@odu.edu (have “Physics 708” in the subject line). *Online meetings* when needed (time TBA- https://odu.zoom.us/j/91453758923) Meeting ID: 914 5375 8923 Passcode: StatPhys24
Course Grades	The final grade is calculated on an absolute scale. There are 100 points possible for this course of which Homework assignments: 40 points Midterm exams: 40 points Final exam: 20 points The grading policy is non-competitive and lenient, but there will be **no curve**. If everyone in the class does well, everyone can get an A. A letter grade is determined only at the end of the term. Grade Requirements $92 \leq$ A < 100 $88 \leq$ A- < 92 $83 \leq$ B+ < 88 $75 \leq$ B < 83 $70 \leq$ B- < 75 $65 \leq$ C+ < 70 $60 \leq$ C < 65 $55 \leq$ C- < 60 $50 \leq$ D < 55 F < 50
Homework	Homework assignments will be set as we progress through the course. All assignments should be submitted electronically (email) as PDF files. **Filename standard**: LastName_HXX.pdf where XX in a homework assignment.

You are encouraged to use LaTeX for preparing your homework reports. You can also use MatLab and Mathematica to present your solution in graphic forms. Doing the homework problems is one of the best ways to learn the material. You should start homework early and get help if needed before the due date.
No individual extensions of assignment submission dates will be given.
Late homework (within 2 days after the deadline) will be accepted with a penalty of 20%. If the homework is late by more 2 days, it will not be accepted.

Mid-term exams

There will be two midterm exams. The midterm examinations will be given during the regularly scheduled class periods. The examinations will emphasize the material in lectures and homework assignments. Your work should be neat and orderly to earn full credit on a problem.
No make-up examinations will be given. In case you have a legitimate reason for missing an exam, consult with me before, or at least within 24 hours after the exam.
The exam dates will be set as we progress through the course (a subject of weather conditions since almost every spring semester we have classes cancelled due to severe weather conditions).
Requests for correction of grading mistakes on exams can be made when the work is returned to you. The requests must be made within two days after getting your grade. Requests should be written. In their request, students must explain why they believe there is a mistake in grading and why they deserve more credit. However, clerical errors (e.g., addition errors) will be corrected immediately.

Final Exam

The final exam will be given on April 25. Time: 8:30-11:30.

Keys to success

In Physics 807 it is vital to both understand the underlying concepts and apply them to problem solving. Advanced reading, consistent participation, and timely completion of assignments are the keys to success. If you work regularly and allocate enough time each day to complete the assignments on time and keep up with the course, you will get the most out of the course both intellectually and grade-wise. Two things that generally do not work are memorization and cramming to catch up just before the examinations (it will be impossible to assimilate all the material). Use the support resources to clarify the material as soon as you feel unsure about something — the instructor is there to help you.

Expectations

For the most efficient use of time in class – you are expected to be prepared for class by reading the material ahead. Once again, it requires discipline, but the pay-offs are considerable.

You are expected to read the sections in the textbook that are covered in class.

Exams and assignments – you are expected to do your work in a neat way (clear diagrams, equations, explanations and numbers). You must show your work and explain your reasoning to earn full credit on a problem.
Finally, you are expected to ask for help when you feel you do not understand something. Do not wait until the final exam to address any problems with the material, most of the time it will be too late.

Professional Integrity	In Physics 807, high professional and ethical standards are promoted. Plagiarism and cheating are serious offenses and may be punished by failure on the exam and failure in the course. The academic integrity code is to be maintained at all times. Using Google, Chegg, and similar resources for getting solutions to homework problems is considered as cheating.
Collaboration	Collaboration in and out of class is strongly encouraged. Because the course is graded on an absolute scale, you will never reduce your grade by helping others — on the contrary, by doing so you will reinforce your own knowledge and improve your performance. Although, before working together or consulting others on any assignments, it is helpful to first tackle the work alone. Activities for which collaboration is not permitted are: examinations, and submission of homework assignments.
Accommodation	Students are encouraged to self-disclose disabilities that have been verified by the Office of Educational Accessibility by providing Accommodation Letters to their instructors early in the semester in order to start receiving accommodations. Accommodations will not be made until the Accommodation Letters are provided to instructors each semester.
Using AI Tools	In this course, we encourage the exploration of AI tools to enrich your learning experience. These innovative tools can offer valuable assistance. However, it is important to note that these tools should be used responsibly and ethically. While AI can be a powerful aid, it is crucial to understand that using AI tools to cheat on assignments is strictly prohibited. The purpose of assignments is to assess your understanding and skills; cheating not only undermines this process but also diminishes your own growth. Therefore, we expect all students to use AI tools as a supplement to their learning, but not as a means to cheat or gain an unfair advantage.

Course Outline

Subjects

1. Statistical description of many-particle systems, phase space, distribution functions.
2. Thermodynamic equilibrium, entropy, temperature, energy conservation
3. Extensive and intensive variables and equilibrium thermodynamic potentials.
4. Gibbs canonical and grand canonical ensembles.
5. Partition function and thermodynamic potentials.
6. Maxwell distribution and thermodynamics of an ideal classical gas
7. Quantum statistics, density matrix
8. Applications to harmonic oscillators and two-level systems
9. Ideal Bose gas, Bose-Einstein condensation
10. Thermodynamics of photons, blackbody radiation
11. Thermodynamics of phonons and thermal properties of solids.
12. Thermodynamics of degenerate Femi gas and electrons in metals.
13. Diamagnetism and paramagnetism of electron gas
14. Chemical and ionization equilibrium
15. Thermoionic and cold emission.
16. Classical and quantum gases of interacting particles. Virial expansion.
17. Thermodynamics of systems with long-range Coulomb interaction.
18. First order phase transition, condensation.
19. Second order phase transitions, long range order and spontaneous symmetry breaking.
20. Ferromagnetic and antiferromagnetic phase transitions.
21. Collisions between particles, kinetic equation, mobility and diffusion.
22. Kinetic coefficients, thermal and electrical conductivity.
23. Fluctuation-dissipative theorem.
24. Gravitational equilibrium and collapse of white dwarfs.