

**PHYS 505.001: Statistical Mechanics and Thermodynamics**  
**CRN: 69762**

**Description:** Thermodynamics and Statistical Mechanics are considered as general methods of description for physical systems with large number of particles.

*Thermodynamics* is treated as a phenomenological approach based on several axioms. Major topics are:

- axioms of thermodynamics;
- thermodynamic functions and potentials (internal energy; enthalpy, Gibbs function);
- equation of state;
- fundamental experiments (e. g., Joule-Thomson experiment; Boyle-Mariotte experiment; Charles-Gay-Lussac experiment);
- entropy;
- heat capacity; heat capacity at constant volume and constant pressure;
- classification of the 4 major equilibrium thermodynamic processes in terms of heat capacity and equation of state;
- relations for thermodynamic coefficients (e. g., temperature coefficients of pressure, volume);
- thermal engines, Carnot thermal machine;
- systems with variable number of particles;
- chemical potential as another thermodynamic parameter;
- phase transitions of the first and second kinds;
- extreme properties of thermodynamic functions;
- thermodynamic equilibrium;
- concepts of non-equilibrium thermodynamics.

Typical processes are analyzed in pressure-volume (PV) and temperature-entropy (TS) coordinate systems. The general results are applied to analysis of specific systems, e. g., radiation, Van-der-Waals gas, and water.

Major topics from *Statistical Mechanics* include:

- phase space, classical and quantum systems;
- derivation of major distribution functions (Maxwell-Boltzmann, Fermi-Dirac, and Bose-Einstein) based on the concept of elementary cells of phase space;
- Liouville's theorem in phase space (based on Hamiltonians of classical and quantum systems);
- thermodynamic transition from classical to quantum systems;
- system of interacting particles; dynamic equilibrium;
- definition of thermodynamic equilibrium from the viewpoint of statistical mechanics;
- statistical definition to equation of state;
- micro- and macro-canonical ensembles of Gibbs;
- derivation of the major distribution functions from the micro-canonical ensemble of Gibbs;
- statistics of particular systems: gas of photons, phonons, electrons in metals with a focus on derivation of equations of state and temperature scaling of heat capacity of those systems;
- theory of fluctuations in thermodynamic systems;
- Einstein's formula for fluctuations;

Major topics from *Physical Kinetics* include:

- the basic concepts of kinetics;
- Markov processes (processes with memory vs processes without memory);
- the Smoluchowski equation;
- the Fokker-Plank equation;
- equation of kinetic balance;
- the Boltzmann kinetic equation.

**Pre-requisites:**

Calculus; Differential Equations; Linear Algebra; Complex Algebra; Matrixes; Grad Quantum Mechanics I. Calculus of functions of two variables and probability theory are routinely utilized throughout this class.

**Lectures:**

Mode: in-person.

Days: Mondays and Wednesdays; from 8:30 am to 9:45 am

Room: 1160 PAIS Building, first floor.

**Problems (a separate class PHYS551.001):**

Tuesdays; from 14:00 till 14:50

Room: 1140 PAIS Building, first floor.

**Instructor:**

Dr. Vitaly Gruzdev, Department of Physics and Astronomy

PAIS Building, room 2012

E-mail: [vgruzdev@unm.edu](mailto:vgruzdev@unm.edu)

**Office Hours:**

Instructor: Wednesdays from 13:00 through 14:00 am. You may also arrange a meeting for another time depending on instructor availability.

**Teaching Assistant:**

TBA

**Textbooks:**

**This course does not follow a particular textbook.** Major sources are lecture slides. They will be e-mailed weekly after lectures. However, there are many useful textbooks on the topics of this class. The list here includes recommended, but optional books for deeper and broader studying some specific topics of the class.

1) L. D. Landau, E. M. Lifshitz, Statistical Physics, 3<sup>rd</sup> Edition, Part 1, Landau and Lifshits Course of Theoretical Physics, Vol. 5, Elsevier, 2020.

[https://www.amazon.com/Course-Theoretical-Physics-Statistical-Part/dp/B01MQZK72C/ref=sr\\_1\\_9?crid=357E8QPEVHRTS&keywords=statistical+physics+landau&qid=1691108674&s=books&prefix=statistical+physics+landau%2Cstripbooks%2C156&r=1-9](https://www.amazon.com/Course-Theoretical-Physics-Statistical-Part/dp/B01MQZK72C/ref=sr_1_9?crid=357E8QPEVHRTS&keywords=statistical+physics+landau&qid=1691108674&s=books&prefix=statistical+physics+landau%2Cstripbooks%2C156&r=1-9)

<https://www.amazon.com/dp/0750633727/ref=olp-opf-redir?aod=1&ie=UTF8&condition=used>

2) R. K. Pathria, Paul D. Beale, Statistical Mechanics, 3d Edition (4th Edition is also OK).

[https://www.amazon.com/Statistical-Mechanics-R-K-Pathria/dp/0123821886/ref=pd\\_lpo\\_1?pd\\_rd\\_i=0123821886&psc=1](https://www.amazon.com/Statistical-Mechanics-R-K-Pathria/dp/0123821886/ref=pd_lpo_1?pd_rd_i=0123821886&psc=1)

<https://www.amazon.com/Statistical-Mechanics-R-K-Pathria/dp/0081026927>

<https://www.elsevier.com/books/statistical-mechanics/beale/978-0-12-382188-1>

<https://www.elsevier.com/books/statistical-mechanics/pathria/978-0-08-102692-2>

Both paper and electronic versions are OK for the class.

3) Linda E. Reichl, A Modern Course in Statistical Physics, 4<sup>th</sup> Edition, Wiley-VCH, 2016.

<https://www.amazon.com/dp/3527413499?tag=gtorg0f-20&linkCode=ogi&th=1&psc=1>

4) Mehran Kardar, Statistical Physics of Particles, 1<sup>st</sup> Edition, Cambridge University Press, 2007.

<https://www.amazon.com/dp/0521873428?tag=gtorg0f-20&linkCode=ogi&th=1&psc=1>

### **Homework assignments:**

There are planned 7 or 8 homework assignments depending on our progress, approximately one assignment each other week. Each assignment typically includes 3 problems based on material of lectures. The assignments will be given throughout the semester a week before they are due. Solutions to homework problems should be turned in either to instructor's mailbox on the due date by 2:30 pm (hard copies) or to instructor's e-mail on the due date by 23:59 (electronic copy). Electronic copies are required to meet major requirements for multiple scanning and re-scanning: use of black ink; resolution at least 600 dpi; black-and-white format is preferable; file format: PDF. Solutions for each homework will be reviewed in class at a lecture that follows the due date of the homework. Homework submitted after a due date, but before an in-class review receives 75% of maximum score (if all problems are solved correctly). Solutions returned after the in-class review are not scored and receive 0 score.

### **Grading:**

The final grade will be based on the homework assignments, mid-term exam, and final exam.

The contributions to the final grade are as follows:

1. Homework: 24% (3% for each homework);
2. Mid-term exam: 32%
3. Final exam: 44%

Two express-test problems will be given throughout the semester at the end of some lectures. A correct answer to each express-test problem provides extra 5% towards the total final grade for the first student who reports a full correct answer. Partial answers can be awarded with 1 to 4%.

**Grade brackets:**

“F”: any grade below 33%

“E”: 33% - 44.9%

“D”: 45% - 59.9%

“C”: 60% - 70%

“B-“: 70.1% - 77%

“B”: 77.1% - 82%

“B+”: 82.1% - 86%

“A-“: 86.1% - 91%

“A”: 91.1% – 95.9%

“A+”: 96.0% - 100%

**Dates:**

Fall 2023 Semester begins: 08/21/2023

Registration for this class ends: 09/01/2023

Fall break: 12 – 13 October 2023

Fall Semester ends: 12/16/2023

**Mid-term exam: 10/23/2023** (no makeup date).

**Final exam: 12/11/2023;** makeup date: **12/13/2023.**

**COVID-19 Health and Awareness.**

UNM is a mask friendly, but not a mask required, community. To be registered or employed at UNM, Students, faculty, and staff must all meet UNM's [Administrative Mandate on Required COVID-19 vaccination](#). If you are experiencing COVID-19 symptoms, please do not come to class. If you have a positive COVID-19 test, please stay home for five days and isolate yourself from others, per the [Centers for Disease Control \(CDC\) guidelines](#). If you do need to stay home, please communicate with me at [vgruzdevAPTunm.edu](mailto:vgruzdevAPTunm.edu); I can work with you to provide alternatives for course participation and completion. UNM faculty and staff know that these are challenging times. Please let me, an advisor, or another UNM staff member know that you need support so that we can connect you to the right resources. Please be aware that UNM will publish information on websites and email about any changes to our public health status and community response.

**Student support sources:**

[Student Health and Counseling](#) (SHAC) at (505) 277-3136. If you are having active respiratory symptoms (e.g., fever, cough, sore throat, etc.) AND need testing for COVID-19; OR If you recently tested positive and may need oral treatment, call SHAC.

[LoboRESPECT Advocacy Center](#) (505) 277-2911 can offer help with contacting faculty and managing challenges that impact your UNM experience.

### **Accommodations**

UNM is committed to providing equitable access to learning opportunities for students with documented disabilities. As your instructor, it is my objective to facilitate an inclusive classroom setting, in which students have full access and opportunity to participate. To engage in a confidential conversation about the process for requesting reasonable accommodations for this class and/or program, please contact Accessibility Resource Center at [arcsrvs@unm.edu](mailto:arcsrvs@unm.edu) or by phone at 505-277-3506.

**Support:** Contact me at [vgruzdevAPTunm.edu](mailto:vgruzdevAPTunm.edu) or in office/check-in hours and contact [Accessibility Resource Center \(https://arc.unm.edu/\)](https://arc.unm.edu/) at [arcsrvs@unm.edu](mailto:arcsrvs@unm.edu) (505) 277-3506.

### **Credit-hour statement**

This is a three credit-hour course. Class meets for two 65-minute sessions of direct instruction for fifteen weeks during the Fall 2022 semester. Please plan for a *minimum* of six hours of out-of-class work (or homework, study, assignment completion, and class preparation) each week.

**Support:** Contact [Center for Academic Program Support \(CAPS\)](#) in case if you need assistance with any items related to the academic side of this class, e. g., if you need more time for the mid-term or final exam. Many students have found that time management workshops can help them meet their goals (consult ([CAPS](#)) website under "services").

### **Title IX:**

Our classroom and our university should always be spaces of mutual respect, kindness, and support, without fear of discrimination, harassment, or violence. Should you ever need assistance or have concerns about incidents that violate this principle, please access the resources available to you on campus. Please note that, because UNM faculty, TAs, and GAs are considered "responsible employees" any disclosure of gender discrimination (including sexual harassment, sexual misconduct, and sexual violence) made to a faculty member, TA, or GA must be reported by that faculty member, TA, or GA to the university's Title IX coordinator. For more information on the campus policy regarding sexual misconduct and reporting, please see: <https://policy.unm.edu/university-policies/2000/2740.html>.

**Support:** [LoboRESPECT Advocacy Center](#), the [Women's Resource Center](#), and the [LGBTQ Resource Center](#) all offer confidential services.

### **Land Acknowledgement**

Founded in 1889, the University of New Mexico sits on the traditional homelands of the Pueblo of Sandia. The original peoples of New Mexico Pueblo, Navajo, and Apache since time immemorial, have deep connections to the land and have made significant contributions to the broader community statewide. We honor the land itself and those who remain stewards of this land throughout the generations and also acknowledge our committed relationship to Indigenous peoples. We gratefully recognize our history.

Faculty Resource: Information provided by UNM's Division for Equity and Inclusion can support building an inclusive classroom, <https://diverse.unm.edu/education-and-resources/programs/index.html>.

### **Citizenship and/or Immigration Status**

All students are welcome in this class regardless of citizenship, residency, or immigration status. Your professor will respect your privacy if you choose to disclose your status. As for all students in the class, family emergency-related absences are normally excused with reasonable notice to the professor, as noted in the attendance guidelines above. UNM as an institution has made a core commitment to the success of all our students, including members of our undocumented community. The Administration's welcome is found on our website: <http://undocumented.unm.edu/>.

### **Respectful and Responsible Learning**

We all have shared responsibility for ensuring that learning occurs safely, honestly, and equitably. Submitting material as your own work that has been generated on a website, in a publication, by an artificial intelligence algorithm, by another person, or by breaking the rules of an assignment constitutes academic dishonesty. It is a student code of conduct violation that can lead to a disciplinary procedure. *Please ask me for help in finding the resources you need to be successful in this course. I can help you use study resources responsibly and effectively.* Off-campus paper writing services, problem-checkers and services, websites, and AIs can be incorrect or misleading. Learning the course material depends on completing and submitting your own work. UNM preserves and protects the integrity of the academic community through multiple policies including policies on student grievances (Faculty Handbook D175 and D176), academic dishonesty (FH D100), and respectful campus (FH CO9). These are in the *Student Pathfinder* (<https://pathfinder.unm.edu>) and the *Faculty Handbook* (<https://handbook.unm.edu>).

**Support:** Many students have found that time management workshops or work with peer tutors can help them meet their goals. These and are other resources are available through [Student Learning Support](#) at the Center for Teaching and Learning.

### **Connecting to Campus and Finding Support**

UNM has many resources and centers to help you thrive, including [opportunities to get involved](#), [mental health resources](#), [academic support including tutoring](#), [resource centers](#) for people like you, free food at [Lobo Food Pantry](#), and [jobs on campus](#). Your advisor, staff at the [resource centers](#) and [Dean of Students](#), and I can help you find the right opportunities for you.