Introduction to Statistical Mechanics

PHYS-4130 (Winter 2025)

Instructor:

Name:	Dr. Jeffrey G. Rau
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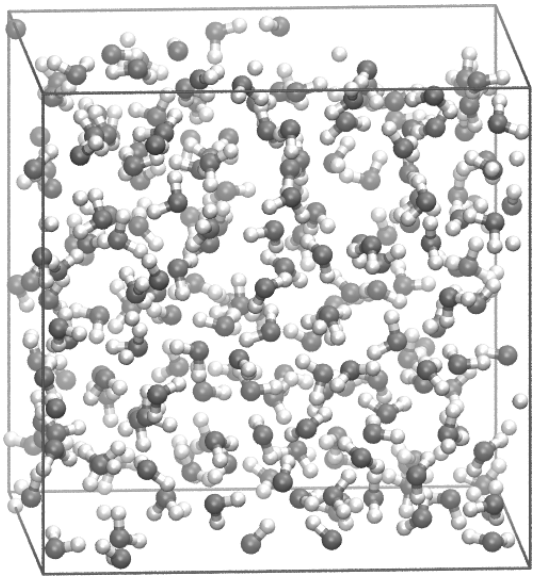

Office hours:

Days:	Monday and Wednesday
Time:	10:30AM to 11:30AM or by appointment

Lectures:

Days:	Monday, Wednesday and Friday
Time:	11:30AM to 12:20PM
Location:	Essex Hall 287

Assessment:

$8 \times 5\% = 40\%$	Assignments	(~ Weekly, lowest two grades dropped)
$2 \times 15\% = 30\%$	Mid-term exams	(Feb. 5th, 2025 and Mar. 14th, 2025)
30%	Final exam	(Cumulative, TBD)

Course Materials:

An Introduction to Thermal Physics, D. V. Schroeder	Optional	$0	Via Leddy
Lectures on Statistical Physics, D. Tong	Optional	$0	Free
Thermal Physics, C. Kittel & H. Kroemer	Optional	$192.99	
Statistical Mechanics, R. Pathria & P. Beale	Optional	$119.99	
Statistical Physics, L. D. Landau & E. M. Lifshitz	Optional	$0	Via Leddy

Course information:

Website:	Brightspace
Prerequisites:	Prerequisites: CHEM-2400 and PHYS-3100 or consent of instructor.
Description:	Thermal equilibrium, diffusive equilibrium; Boltzmann and Gibbs distributions, canonical and grand canonical partition functions; thermodynamics from statistical mechanics, entropy, work, heat; Helmholtz free energy, Gibbs free energy, enthalpy, Gibbs-Duhem relation, equations of state, Maxwell relations, response functions; Planck distribution and thermal radiation, Fermi-Dirac distribution and the Fermi gas, Bose-Einstein distribution and the Bose gas, ideal gas; chemical reactions; binary mixtures; phase transitions; elementary kinetic theory.

Course Outline

A (tentative) course outline is given below. The content of the course is, in the end, determined by what is covered in the lectures.

Motivation and Review

- What is *statistical mechanics*?
- *Review:* Thermodynamics
- *Review:* Probability, statistics, combinatorics

Micro-canonical Ensemble

- Discrete states, two-level systems
- Micro- and macro-states, fundamental postulate
- Entropy, equilibrium and temperature
- Pressure and volume

Canonical and Grand-Canonical Ensemble

- Boltzmann factor, partition functions
- Free energy, entropy and specific heat
- Ideal gases
- Planck's law, Thermal radiation, Photons
- Grand canonical ensemble, chemical potential, Gibbs free energy

Quantum Gases

- Identical and distinguishable particles; Fermi and Bose statistics
- Classical ideal gases (revisited)
- Fermi and Bose gases
  - Fermi surfaces
  - Specific heat, degeneracy
  - Bose condensation

Phase Transitions

- Definitions; Continuous and discontinuous phase transitions
- Spontaneous symmetry breaking, order parameters
- Ferromagnetic Ising model, mean field theory

Lectures

The main delivery method for the course material will be through in person lectures during our scheduled lecture times.

- There will be **three 50 minute lectures per week**, held during our scheduled class period (11:30AM-12:30PM, Monday, Wednesday and Friday) in Essex Hall 287.
- During the week of March 17th I will be away at a conference for part or all of the week. Alternative arrangements will be discussed closer to this date (e.g. substitute lecturer, recorded lectures).

Assignments

Assignments to be done as homework will be given (approximately) every week. Deadlines will be typically be one week after the assignment is posted (the precise date and time will be listed on the assignment). **The lowest two assignment grades will be dropped.**

- Homework must be prepared in a professional and legible manner and must be turned in either as a *hard-copy* or *electronically* through Brightspace. If submitting electronically, handwritten pages must be scanned and uploaded as a *single* PDF file.
- Feedback will be provided electronically for an electronic submission, and a marked PDF will be returned via Brightspace as an attachment. For hard copies feedback will be written on the assignment and it will be returned in class.
- **No late homework will be accepted** – after the deadline it will be given a mark of zero.
- While discussing the problems with your peers is encouraged, homework is to be written and submitted *individually* and should represent *your own work*.
- Copying from other students or from *any other source* is *not allowed* (this includes websites and discussion boards). Plagiarism and academic dishonesty are serious offences and will be addressed using university guidelines and policies. The use of generative AI *is* permitted in this course as a tool to aid and enhance understanding, but not as a substitute for learning or as a substitute for producing original work. All submitted homework should reflect your own thoughts, ideas and reasoning and (if necessary) students may be held responsible for defending their solutions.

Mid-term exams

There will be two mid-term exams, each worth 15% of your grade. They will be written during our scheduled lecture time and they will be a conventional closed book and closed notes exam.

- *Dates*: **February 5th, 2025 and March 14th, 2025**
- Exams will consist primarily of worked problems, similar to (but not identical to) the problems that have been assigned for the homework. A short-answer portion covering more conceptual questions may also be included at my discretion.
- There will be *no make up exam* for the mid-terms. If a mid-exam is missed, with acceptable medical (or equivalent compassionate) reasons, the weight of that exam will be transferred to the final exam.

Final exam

The final exam will be a three-hour written comprehensive exam drawn from *all* of the course, at similar level to the mid-terms and homework. The exam will take place over *three hours* on our scheduled exam day. The exam will be a conventional closed notes/book exam.

- *Date:* **To be determined** (Final exam period: April 7th, 2025 - April 17th, 2025)
- If your grade on the final exam is higher than your *lowest* mid-term exam grade, the final exam grade will replace it.
- A make-up examination for the final exam will only be administered with acceptable and verifiable medical (or equivalent compassionate) reasons, handled through the official University of Windsor channels and procedures.

Technical

- All email correspondence must be from your University of Windsor email address; email from other addresses will be ignored. Please include the course number (PHYS-4130) in the subject line any emails so I can get to it quickly.
- If you have a conflict with the posted office hours, you are also free to ask me questions at any time via email (though I will not guarantee a response rate, I will try my best). Alternatively, you can also arrange a scheduled time for a one on one (in person or virtual) discussion.
- If there are technical difficulties in submitting an assignment or an exam through Brightspace, you may email it directly to me (from your offical University email account).
- For scanning of hand-written pages there are many good smartphone applications that directly produce PDFs. Some examples include Office Lens (Android, iOS) and Adobe Scan (Android, iOS).

Miscellaneous

- *Voluntary withdrawal deadline*: **March 16th, 2025**
- *Reading week:* **February 15th, 2025 - February 23rd, 2025**
- As per senate rules, grades are percentages, reported as whole numbers.
- The content of the course is, in the end, determined by what is covered in the lectures and not by the outline provided in the syllabus.
- The Student Perceptions of Teaching (SPT) will be complete during the last two weeks of class (time will be provided at the start of a lecture to fill in the online form)..
- Students in need of university-recognized accommodations (via student accessibility services) should make themselves known to the instructor at the beginning of the course and discuss what arrangements are needed and how they might be accommodated.
- University of Windsor's student code of conduct provides that all students are expected to commit to a code of behavior based on dignity and individuality, and respect for the rights and property of others.

- Anyone exhibiting disruptive behavior during lectures will be asked to leave. Disciplinary actions will be taken for failure to follow directions.
- Plagiarism and academic dishonesty are serious offences and will be addressed using university guidelines and policies.

- For help addressing mental or physical health concerns, refer to the wellness outreach office for a full list of on-and off-campus resources available to students.
- The Ministry of Colleges and Universities now requires that all syllabi contain information on the cost of any required or optional course materials. For each resource on the first page of the syllabus I have included (a) whether it is optional or required and (b) the price (taken from a large online retailer at the time this syllabus was prepared). For resources that are either free or available at no additional cost via institutional subscriptions I have listed the cost as zero and provided a link. Second-hand or older editions (if they exist) of these resources are similar enough in content to be interchangeable with the newest version.