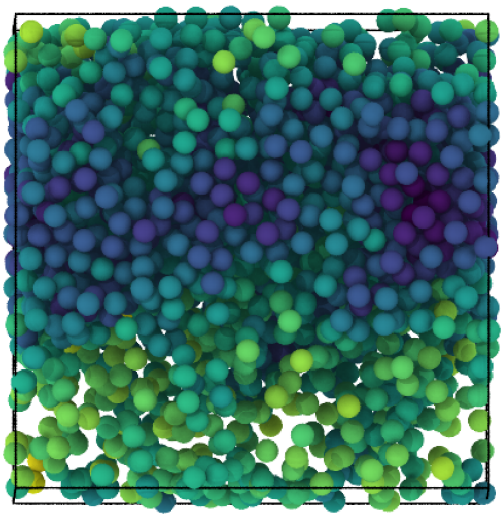
Statistical Physics I

PHYS-9130 (Winter 2022)



Instructor:

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Office hours:

Days: Tuesday and Thursday
Time: 1:00PM to 2:00PM or by appointment

Lectures:

Days: Tuesday and Thursday
Time: 11:30AM to 12:50PM
Location: Essex Hall 287 or Blackboard Collaborate

Assessment:

50%	Assignments	(~ every 1.5 weeks; lowest grade dropped)
20%	Mid-term exam	(Mar. 8th, 2022)
30%	Final exam	(TBD)

Materials:

Recommended text:	*Statistical Physics of Particles*, M. Kardar	ISBN: 0521873428
Useful resources:	*Lectures on Statistical Physics*, D. Tong	
	Statistical Mechanics, R. Pathria & P. Beale	ISBN: 0123821886
	Statistical Physics, L. D. Landau & E. M. Lifshitz	ISBN: 0750633727
	Thermal Physics, C. Kittel & H. Kroemer	ISBN: 0716710889

Course information:

Website:	Blackboard
Prerequisites:	Undergraduate statistical mechanics (PHYS-4130), and graduate quantum mechanics (PHYS-8100) are *strongly* recommended.
Calendar Description:	Review of thermodynamics; information theory. The many-body problem in quantum mechanics, particle number representation. Statistical (density) matrix. The perfect gas, real gases, dense plasma, applications.

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. We will be loosely following *Statistical Physics of Particles* by M. Kardar. For an alternative perspective *Statistical Mechanics* by R. Pathria & P. Beale covers much of the same material, though in a different order and with a different emphasis.

Motivation and Review

- What is *statistical mechanics*?
- *Review:* Thermodynamics

Kinetic Theory

- *Review:* Hamiltonian Mechanics
- Liouville's Theorem
- Bogoliubov–Born–Green–Kirkwood–Yvon hierarchy
- Boltzmann Equation and the H-Theorem
- Equilibrium, conservation laws and hydrodynamics

Classical Statistical Mechanics

- Postulates of Statistical Mechanics
- Ensembles (Micro-Canonical, Canonical, Grand-Canonical)
- Non-interacting particles
- Interacting particles
  - Cumulant and Cluster Expansions
  - Van der Waals Equation, Virial coefficients
  - Mean-field theory and phase transitions; Gibbs inequality

Quantum Statistical Mechanics

- *Review:* Density Matrix formulation of quantum mechanics
- Postulates and Ensembles
- Eigenstate Thermalization Hypothesis
- Linear response; Fluctuation-dissipation theorem
- Polyatomic gases; Vibrations and Normal Modes; Phonons
- Ideal quantum gases
  - Identical particles; Number representation
  - Fermi gas
  - Bose gas; Bose condensation

Lectures

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

- There will be **two 80 minute lectures per week**, held during our scheduled class period (11:30AM-12:50PM, Tuesday and Thursday) in Essex Hall 287. For students attending remotely, these will be live-streamed and recorded.
- On Mar. 8th, 2022 no lecture will take place, as this time period will be used for the mid-term exam.
- Students will be expected to follow all university policies with regard to mask wearing, vaccination, distancing and any other public health measures while on campus.

When public health measures preclude in person lectures (at least until Jan. 31st, 2022), we will fall back to synchronous remote lectures delivered during our scheduled time via Blackboard Collaborate. They will be recorded and the link will be posted to Blackboard and Microsoft Stream after each session.

Assignments

Assignments to be done as homework will be given (approximately) every week and a half. Deadlines will be typically be one or two weeks after the assignment is posted (the precise date and time will be listed on the assignment). **The lowest assignment grade 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 Blackboard. If submitting electronically, handwritten pages must be scanned and uploaded as a *single* PDF file. If prepared electronically, the final output format must be a single PDF file.
- Feedback will be provided electronically for an electronic submission, and a marked PDF will be returned via Blackboard as an attachment in the “Feedback to Learner" section. 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. If necessary, each student will be responsible for defending their homework solutions.

When public health measures preclude on campus activity (at least until Jan. 31st, 2022) only electronic submission will be possible.

Mid-term exam

There will be a mid-term exam, worth 20% of your grade. The exam will be written in a take home format, consisting primarily of worked problems, similar to (but not identical to) the problems that have been assigned for the homework.

- *Date*: **March 8th, 2022**
- The exam will take place over a window of *six hours* which overlaps with the scheduled class period and will be open notes / open book and will be submitted in a similar way to the homework. It will be designed as a 90 minute exam.
- Collaboration with other students in the class or anyone else not in the class (this includes websites and discussion boards) is strictly forbidden – **you must to do these exams entirely on your own**. You may be required to sign and submit an affirmation that will adhere to these policies when you submit the exam. If necessary, each student will be responsible for defending their submitted exams.
- There will be *no make up exam* for the mid-term. 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 written comprehensive exam drawn from *all* of the course, at similar level to the mid-term and homework. It is worth 30% of your grade.

- *Date:* **To be determined** (Final exam period: April 20th, 2022 - April 29th, 2022)
- The exam will take place over a window of *twenty-four hours* which overlaps with the scheduled period and will be open notes / open book and will be submitted in a similar way to the homework. It will be designed as a 180 minute exam.
- If your grade on the final exam is higher than your 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-9130) 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.
- Files submitted electronically should have a filename that indicates the course number (PHYS-9130), what is being submitted and your full name.

- If there are technical difficulties in submitting an assignment or an exam through Blackboard, 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*: **April 16th, 2022**
- *Reading week:* **February 19th, 2022 - February 27th, 2022**
- For a medical absences the requirement to submit medical notes for the Winter 2022 semester has been waived, and students should use the self-report of illness interface.
- 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 Evaluation of Teaching (SET) forms will be completed online through UWinsite Student in the final two weeks of the semester. Instructions are available here.
- 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.