Thermal Physics

PHY B52 - Winter 2022

Lecture	Tuesday	1:00 pm - 3:00 pm	BV 260
TUT 02	Wednesday	3:00 pm - 5:00 pm	IC 328
TUT 03	Wednesday	9:00 am - 11:00 am	IC 328

Instructor: Johann Bayer **Email:** jbayer@utsc.utoronto.ca **Course Website:** q.utoronto.ca

Office Hours (Tentative)

Tuesday	10:00 am - 11:00 am
Thursday	10:00 am - 11:00 am
Thursday	2:00 pm - 3:00 pm

Course Description, Learning Outcomes, and Requirements

The course will start with the idea of thermal equilibrium; an extension to the concepts of energy, heat, and work; and the definitions of temperature and entropy. We will continue with a study of mechanical and chemical equilibrium; the laws of thermodynamics; and examples and applications to heat engines, refrigerators, free energy, and chemical thermodynamics. We will conclude the course with an introduction to the statistical concepts which underlie macroscopic thermodynamics and provide the bridge between the microscopic and macroscopic pictures, using quantum ideal gases as our example.

By the end of the course students will be able to:

- Identify and define the basic vocabulary used in Thermodynamics and Statistical Mechanics.
- Recognize the connections and differences between the microscopic and macroscopic descriptions of thermodynamic systems composed of large numbers of particles.
- Use the Laws of Thermodynamics to derive the key macroscopic properties of the two-state paramagnet, the ideal gas, and the Einstein solid, starting from a microscopic statistical description.
- Apply the fundamental principles of thermal physics and solve problems and conceptual questions involving ideal and real thermodynamical processes.
- Develop and implement problem-solving strategies useful in the analysis of examples and questions related to the description, behaviour, and evolution of thermodynamic systems.
- Identify the main ideas and core physical principles in Thermal Physics, and demonstrate their knowledge through deliberate time management and reflective judgement of the questions and problems in tutorial work, tests, and the final exam.
- Self-assess the level of confidence in the acquired knowledge of the core concepts and ideas in the fields of Thermodynamics and Statistical Mechanics through the decision-making process associated with the allocation of resources during tests and the final exam.
- Review and update the mathematical toolbox of quantitative and analytical skills relevant and useful in the scientific endeavour in general, and to the study of Physics in particular.

Course Pre-Requisites: Physics II (PHYA21); Calculus of Several Variables I (MATB41)
Course Corequisite: Calculus of Several Variables II (MATB42)

Required Materials

- **Calculator:** A scientific, non-programmable, and non-graphing calculator is required.

- **Textbook:** ***An Introduction to Thermal Physics*** by Daniel V. Schroeder (OUP Oxford 2021)

The schedule found at the end of this document indicates the chapters and sections you must read **before** each lecture or the release of a lecture video. The textbook also provides the conceptual questions and detailed problems that will be the subject of the weekly problem sets, reading quizzes, and tutorial work.

- **Technical Requirements for Remote and Online Learning:**

Please review the minimum and recommended technical requirements for learning in the remote and online environment. You must have access to a fast and reliable Internet connection for any course components that might end up being converted to synchronous online delivery from the expected in-person schedule. This includes, but is not limited to, tutorial sessions, tests, and the final exam. Use of a computer (laptop or desktop) instead of a mobile device (smartphone or tablet) will be critical during any electronic forms of assessment. It is strongly recommended that you connect via wire (Ethernet) to your modem or router instead of using a wireless access (WiFi) to ensure stability and reduce interference.

Additionally, you will be required to produce scans of handwritten work in PDF format for tutorial work and, in the event of a transition to online delivery, tests and the final exam. This can be accomplished using a dedicated scanner, a document scanner app using the camera in your smartphone, or a direct-to-digital annotating solution. More details and suggestions will be available in the course website.

Grading Scheme and Components

Component	%	Due Date
Reading Quizzes	5	Ongoing (Pre-Lecture)
Tutorial Work	20	Ongoing (Weekly Tutorials)
Test #1	15	Week 05 (Tentative)
Test #2	20	Week 09 (Tentative)
Final Examination	40	Exam Period (April 13 - 29)

Reading Quizzes (5%)
Each week on the course website you will be asked a set of questions from the assigned readings for the upcoming week. You will have until **11:55 am** on **Tuesday** to submit your answers. Each quiz is worth **5 points**, and your final grade is the total sum of all quizzes up to a maximum of **50 points**. Use the **Class Schedule** found at the end of this document to prepare for the lectures (discussions or videos), and the reading quizzes. While missing or late submissions will be assigned a score of **0 points**, the number of quizzes in the course provides you with the opportunity to make up for any low scores received.

Tutorial Work (20%)
Prior to each tutorial session you will have the opportunity to review a problem set containing relevant examples and problems for that week. During the tutorials, whether in-person or synchronously online on Zoom depending on the latest UTSC Regulations, we will discuss the most important points from the problem set as well as any difficulties you may have encountered in your weekly readings.

Tutorial Work (continued from previous page ...)
After the end of each session a set of problems and questions derived from the tutorial discussions will be made available. Each student will then be required to submit their individually-completed work on these problems and questions. In order to submit the answers to these problems and questions you will be required to digitize the completed work either through the use of a scanner or by converting photos into acceptable PDF files. When using a mobile device, the use of a document scanner app is strongly recommended. While missing submissions will receive a score of **0 points** and late submissions will be assigned a penalty described in the course website, your final grade will be calculated as the average of the **best 10** results, providing you with the opportunity to make up for any low scores received.

Test #1 (15%)
This **2-hour**[1] long test will be scheduled *tentatively* during **Week 5**. Content includes all lecture discussions, assigned textbook readings, problem sets, and tutorial work, up to and including the material discussed in the week prior to the test.

Test #2 (20%)
This **2-hour**[1] long test will be scheduled *tentatively* during **Week 9**. Content includes all lecture discussions, assigned textbook readings, problem sets, and tutorial work, up to and including the material discussed in the week prior to the test.

Final Examination (40%)
The **3-hour**[2] long final examination will be scheduled during the final exam period of **April 13 - 29**. Content for the final examination includes all lecture discussions, assigned textbook readings, problem sets, and tutorial work.

Format and Allowed Aids - Tests & Final Examination
Both tests and the final examination will include conceptual questions in multiple-choice and short-answer format, as well as detailed problems.[3] The only aids allowed are your non-programmable and non-graphing scientific calculator, and a hand-written, double-sided, and letter-sized aid sheet that may not include explicit problem solutions. Photocopies or computer printouts are not allowed.

Class Policies

Copyright Notice
Course videos and all additional course materials, including all assignments and various assessment instruments, belong to your instructor, the University, and/or other sources depending on the specific facts of each situation, and are protected by copyright. Do not download, copy, or share any course materials or videos without the explicit permission of the instructor. In addition, please note that recording or the use of any form of screen capture on the content of any assessment instrument is not permitted and constitutes both a breach of copyright, also known as copyright infringement, and a violation of the University of Toronto's *Code of Behaviour on Academic Matters*.

Name and Student Number
Any work you hand in physical form as paper hard-copy must clearly indicate your name and student number, this includes tutorial work, tests, and the final exam. Failing to meet this requirement will result in a 10% deduction, provided we are able to identify the work as yours. If we are unable to identify the work as yours, a grade of zero will be awarded.

[1] In the event that UTSC guidelines require online delivery of a test, its length will be increased to 2.5 hours.
[2] In the event that UTSC guidelines require online delivery of the final exam, its length will be increased to 4.0 hours.
[3] In the event that UTSC guidelines require online delivery of a test or the final exam, you must submit work for the detailed problems in that test or final exam following the same protocols used for the submission of tutorial work problems.

Email Communications

If you want to ask a question via email, please first check the various threads in the PeppeR section of the course website. Quite likely, you are not the only person with that same question, and if that question has already been asked, you will find the answer there. If the question has not been asked, go ahead and post it yourself instead of sending it by email. This way you will also help other students facing the same issue. These discussions are monitored regularly by the course instructor and your peers, making it the best way of communicating for various queries of a diverse nature.

However, if the electronic forums are not the best place for your specific concern, make sure to send your email from an official **utoronto.ca** address (e.g., your UTmail+ account), as all other addresses will be filtered out automatically. For a quicker response time include the code **PHYB52** in the subject line of your message.

While I rarely reply to emails during weekends, during weekdays I will reply to all emails within a period no greater than 24 hours.

Policies on In-Person Lectures and Tutorials

- As per the latest UTSC Regulations concerning COVID-19, all students must wear appropriate masks, be fully vaccinated, and complete their UCheck screening prior to attendance to each in-person lecture and tutorial session.
- Lectures start at 1:10pm and end at 3:00pm. Tutorials run from 9:10am to 11:00am and 3:10pm to 5:00pm. Late arrival or early departure is inappropriate and highly disruptive so please be respectful of the learning environment.
- Regarding anything that you want to use in the classroom: if you are not using it to perform a task specifically related to what we are doing in class at that very moment, you must put it away. This includes but is not limited to cell phones, laptop computers, tablets, and other electronic devices.
- Consumption of food or drinks in the classroom during lectures or tutorials is not permitted. The removal of masks for eating or drinking in the classroom is against current policies and regulations, and it further creates unwanted distractions that negatively affect the learning environment.

Absences

In order to ensure fairness in the assessment of all students, there will be no default makeup options for any term work. In the case of a **valid** and **documented** problem that supports missed tutorial work the grade will be calculated on the basis of all other submitted work. In the case of a valid and documented problem that supports an absence to the first test, the second test will have its weight increased accordingly. In the case of a valid and documented problem that supports an absence to the second test, the final examination will have its weight increased accordingly.

Exceptional circumstances requiring a makeup test would be reviewed on a case-by-case basis. Any resulting makeup tests will be scheduled as oral examinations to be conducted in-person or via Zoom, depending on the latest UTSC Regulations.

All valid and documented absences must be declared through **both** the Absence Declaration in ACORN **and** the DPES Self-declaration Absence Form, and the onus is fully on the student to contact promptly the course instructor. Additionally, absences that are the result of a non-COVID health-related problem must be documented with a completed Verification of Illness or Injury form. Please note that you might be required to provide additional supporting documentation to your instructor.

Academic Integrity and Respect for the Academic Endeavor

Academic integrity is essential to the pursuit of learning and scholarship in a university, and to ensuring that a degree from the University of Toronto is a strong signal of each student's individual academic achievement. As a result, the University treats cases of cheating and plagiarism very seriously. The University of Toronto's *Code of Behaviour on Academic Matters:*

https://governingcouncil.utoronto.ca/media/15068/view

outlines the behaviours that constitute academic dishonesty and the processes for addressing academic offences. Potential offences include, but are not limited to:

- In papers and assignments: Using someone else's ideas or words without appropriate acknowledgment; submitting your own work in more than one course without the permission of the instructor; making up sources or facts; obtaining or providing unauthorized assistance on any assignment; using someone else's clicker or multiple clickers for participation grades; posting course materials to external sites or accessing answers from online repositories or paid-for-solution sites.
- On tests and exams: Using or possessing unauthorized aids; looking at someone else's answers during an exam or test; misrepresenting your identity; posting course materials to external sites or accessing answers from online repositories or paid-for-solution sites.
- In academic work: Falsifying institutional documents or grades; falsifying or altering any documentation required by the University, including (but not limited to) doctor's notes.

All suspected cases of academic dishonesty will be investigated following procedures outlined in the *Code of Behaviour on Academic Matters*. If you have questions or concerns about what constitutes appropriate academic behaviour or appropriate research and citation methods, you are expected to seek out additional information on academic integrity from your instructor or from other institutional resources (see https://www.utsc.utoronto.ca/vpdean/academic-integrity).

Course Support

Access*Ability*

Students with diverse learning styles and needs are welcome in this course. In particular, if you have a disability/health consideration that may require accommodations, please feel free to approach me and/or the Access*Ability* Services Office as soon as possible. I will work with you and Access*Ability* Services to ensure you can achieve your learning goals in this course. Enquiries are confidential. The UTSC Access*Ability* Services staff (located in AA142) are available by appointment to assess specific needs, provide referrals and arrange appropriate accommodations. Contact by phone (416) 287-7560 or email at ability@utsc.utoronto.ca

Lecture Videos

Lecture videos will be available weekly on Tuesday afternoon. Depending on the latest UTSC Regulations concerning in-person course components this will be either as a substitute for a cancelled in-person lecture discussion or as a supplementary component useful for review. All lecture videos will expire the following week on Friday morning, approximately 10 days after being released.

PeppeR on Quercus

The course website supports electronic forums useful for questions and discussions on course content, conceptual and detailed problems, textbook readings, as well as any issues relating to administrative aspects of the course such as deadlines and scheduling.

It is recommended that you check the threads on a regular basis to keep on top of current issues. You can subscribe to the various threads in order to receive email notifications when new posts are available.

Class Schedule

This schedule is ***tentative*** and might change during the term in order to accommodate for variations in the lecture discussions or lecture videos in response to student performance and understanding of the various topics.

Please note that it is your responsibility to read the assigned sections **before** each lecture discussion or lecture video, and in preparation for the completion of the respective reading quiz.

The lecture discussions or lecture videos will **not** be a direct repetition of the basic material found in the textbook. Instead, we will concentrate on important and difficult aspects of the theory and concepts from your textbook readings.

A minimum understanding of the basic concepts from the assigned readings will be the assumed starting point for each lecture discussion or lecture video. As a result, failing to complete the textbook readings before engaging with the lecture component will significantly affect your ability to understand the material presented.

Week # Date	**Lecture Video**	**Tutorial Discussion**
Week 01 Jan. 11-12	**Equilibrium, The Ideal Gas, Equipartition** Chapter 1: Sections 1 - 3	**Course Organization**
Week 02 Jan. 18-19	**Heat, Mechanical Work, Heat Capacity** Chapter 1: Sections 4 - 6	**Problem Set #01**
Week 03 Jan. 25-26	**Two-State Systems, The Einstein Solid** Chapter 2: Sections 1 - 2	**Problem Set #02**
Week 04 Feb. 01-02	**Interacting Systems, Large Systems** Chapter 2: Sections 3 - 4	**Problem Set #03**
Week 05 Feb. 08-09	**The Ideal Gas, Entropy** Chapter 2: Sections 5 - 6	**Problem Set #04**
Week 06 Feb. 22-23	**Temperature, Entropy, Paramagnetism** Chapter 3: Sections 1 - 3	**Problem Set #05**
Week RW Feb. 22-23	**Reading Week** Reading Review: Chapters 1 - 2	**Problem Set #06**
Week 07 Mar. 01-02	**Equilibrium: Pressure & Chemical Potential** Chapter 3: Sections 4 - 6	**Problem Set #07**
Week 08 Mar. 08-09	**Heat Engines, Refrigerators** Chapter 4: Sections 1 - 2	**Problem Set #08**
Week 09 Mar. 15-16	**Free Energy: Available Work & Equilibrium** Chapter 5: Sections 1 - 2	**Problem Set #09**
Week 10 Mar. 22-23	**Boltzmann Factors, Averages, Equipartition** Chapter 6: Sections 1 - 3	**Problem Set #10**
Week 11 Mar. 29-30	**Maxwell, Partition Functions, The Ideal Gas** Chapter 6: Sections 4 - 7	**Problem Set #11**
Week 12 Apr. 05-06	**Gibbs Factors, Bosons & Fermions** Chapter 7: Sections 1 - 3	**Problem Set #12**