PHYS 4050, Fall 2024

Thermodynamics and Statistical Physics

Mode	onsite	
Lectures	Mon, 1:30 pm – 2:50 pm	RM 2407
	Fri 9:00 am – 10:20 am	RM 2407
Tutorials	Monday 5:30 pm – 6:20 pm	RM 4504
	Tuesday 5:00 pm – 5:50 pm	RM 4620
Instructor	Prof. Shiming LEI E: phslei@ust.hk	Room 4482
TAs	Yifan GAO (ygaocr@connect.ust.hk) Yifan JIANG (yjiangeb@connect.ust.hk)	
Office hours	Thursday 9:30 am – 10:30 am	RM 4482
Prerequisites	PHYS 2022.	

Course Plan

PHYS 4050 is a required course that acts as the bridge to link the knowledge in elementary physics, i.e., Classical and Quantum Mechanics, to some advanced topics in Thermal Physics. Key topics include the laws of thermodynamics, entropy, thermodynamic relations, free energies and thermodynamic potentials, phase transformation and chemical thermodynamics; two elementary types of quantum statistics: Bose-Einstein and Fermi-Dirac statistics, and their relation to the Boltzmann statistics; degenerate Fermi gas; blackbody radiation; Bose-Einstein Condensation; Debye model of solids.

Weekly course Topic

Topics	Lecture #	Lecture Date	Contents
Energy in Thermal Physics	1, 2	2,6 Sept	Equation of States; Equipartition theorem; First Law of Thermodynamics; Ideal gas
Energy in Thermal Physics; Entropy and the Second Law	3,4	9, 13 Sept	Heat Capacity of Solids; States of Matter; Microstate, Macrostate and Multiplicity; Two-state Paramagnet; Einstein Solid; The postulate of equal a priori probabilities; Stirling approximation; Multiplicity for monatomic ideal gas;

Entropy and the Second Law	5,6	16, 20 Sept	Boltzmann's Law of Entropy; the Second Law of Thermodynamics; Energy exchange and irreversibility;
Interactions and Implications	7,8	23, 27 Sept	Temperature and thermal equilibrium; the Third Law of Thermodynamics; Paramagnetic solid; Mechanical Equilibrium; Thermodynamic Identity
Heat Engines and Refrigerators	9,10	30 Sept, 4 Oct	Chemical Potential; Maximum Thermal Efficiency; Carnot Cycle and Carnot Efficiency; Refrigerators; Clausius Inequality
Heat Engines and Refrigerators; Free Energy and Chemical Thermodynamics	11	7 Oct	Real Engines; Enthalpy
NA	Midterm	14 Oct	NA
Free Energy and Chemical Thermodynamics	12	18 Oct	Helmholtz Free Energy; Gibbs Free Energy; Maxwell relation
Free Energy and Chemical Thermodynamics	13,14	21, 25 Oct	Magnetic Work and Related Thermodynamic Potentials; Free Energy and Equilibrium; Gibbs Duhem Relation;
Free Energy and Chemical Thermodynamics; Boltzmann Statistics	15,16	28 Oct, 1 Nov	Phase Transformation; Clausius-Clapeyron Relation; Van der Waals Equation; Joule-Thomson Process; Canonical distribution; Partition Function
Boltzmann Statistics	17,18	4, 8 Nov	Maxwell speed distribution; Partition Function and Free Energy; Partition function and idea gas
Quantum Statistics	19, 20	11, 15 Nov	Bose Statistics; Fermi Statistics; Degenerate Fermi gas;
Quantum Statistics	21,22	18, 22 Nov	Electromagnetic Radiation; Planck Distribution; Blackbody radiation; Stefan-Boltzmann Law; Bose-Einstein Condensation; Debye Solids

Learning Outcomes

At the conclusion of this course, students should be able to apply the basic principles of thermodynamics and statistical mechanics in order to solve problems about the behavior of systems containing a very large number of particles. In particular, students should be able to:

1. Understand the fundamental concepts and technical terms in thermal physics.
2. Apply laws of thermodynamics and statistical physics to real applications in physical science and related topics.
3. Solve real and hypothetical problems by applying the mathematical methods of statistical physics.
4. Students should also be able to present their solutions to problems using concise but clearly reasoned and well justified arguments.

Textbook

Daniel V. Schroeder, *An Introduction to Thermal Physics*, 1st Ed.

The course will cover the above textbook except chapter 1.7, 4.3, 4.4, 5.4-5.6 and 8. When time permits, these skipped contents will be taught.

Other books

Blundell and Blundell, *Concepts in Thermal Physics*, 2nd Ed. (Oxford).

Web page

All course announcements, homework assignments, and other course materials will be posted at the PHYS 4050 site on Canvas (https://canvas.ust.hk/).

If you have any questions or comments, you are encouraged to discuss them with me, the TAs, and your classmates in the Discussion forum on Canvas.

Assessment

There will be homework problem sets, plus midterm and final exams. The weighting is 30% homework (10 sets of homework), 30% midterm exam, and 40% final exam. Additionally, we have three challenging bonus tasks (in total 5/100 to the final score) throughout this term.

Instructions for the problem sets are given separately. Late submission of homework will result in score reduction.

Academic Integrity

In this course, you will be expected to uphold the university's Academic Honor Code (https://pg.ust.hk/current-students/regulations/academic-honor-code). Any instances of cheating or plagiarism will be dealt with according to university policies on academic integrity (https://acadreg.ust.hk/generalreg.html) (http://ugadmin.ust.hk/integrity/student-1.html) (https://rpghandbook.ust.hk/student-conduct-and-academic-integrity).