



PHYS7902

Statistical Physics

Session 1, Weekday attendance, North Ryde 2020

Department of Physics and Astronomy

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General Information

Unit convenor and teaching staff

Lecturer

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12-1 Wednesdays; 1-2 Thursdays

Lecturer and Unit convener

Daniel Terno

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Credit points

10

Prerequisites

Admission to MRes

Corequisites

Co-badged status

Unit description

This unit presents an introduction to thermodynamics and statistical physics. The first half of the course begins with a definition of state functions and macroscopic variables such as temperature, pressure, and volume which characterise the state of a system, introducing the equation of state. Entropy is introduced via an information theoretic argument and applied to counting microstates of a system. We define the zeroth through the third laws of Thermodynamics and introduce the $T dS$ relations. The role of potentials in simplifying thermodynamic predictions is explored. The concepts of reversible and irreversible engines and refrigeration cycles are covered in detail. We cover the ideal gas law and first order corrections for the Van der Waals gas. In the second half we introduce thermodynamical equilibrium as a postulate of statistical mechanics. We derive the partition function via the principle of maximum entropy. The Gibbs paradox is described as are macro, micro and grand canonical ensembles with examples using the ideal gas and Van der Waals gas. A short introduction is given to quantum statistical mechanics and Fermi-Dirac and Bose-Einstein distributions are derived. A range of interacting statistical systems such as ferromagnetism are explored and we introduce the study of order parameters and phase transitions.

Important Academic Dates

Information about important academic dates including deadlines for withdrawing from units are available at <https://www.mq.edu.au/study/calendar-of-dates>

Learning Outcomes

On successful completion of this unit, you will be able to:

ULO1: interpret and apply the 0th-3rd laws of thermodynamics, some principal ideas from kinetic theory and the postulates of statistical mechanics

ULO2: use the properties and mathematical descriptions of key systems including ideal gases, quantum gases, Bose and Fermi statistics and apply the concepts to physical systems.

ULO3: explain the relationship between the different levels of description of thermodynamics and statistical mechanics, and construct models for selected physical systems using these descriptions.

ULO4: apply mathematical approaches to solve ideal and practical problems in kinetic theory, thermal and statistical physics.

ULO5: present physical arguments in thermostatics effectively to other physicists both in writing and orally.

Assessment Tasks

Coronavirus (COVID-19) Update

Assessment details are no longer provided here as a result of changes due to the Coronavirus (COVID-19) pandemic.

Students should consult [iLearn](#) for revised unit information.

[Find out more about the Coronavirus \(COVID-19\) and potential impacts on staff and students](#)

General Assessment Information

If you receive [special consideration](#) for the final exam, a supplementary exam will be scheduled after the end of the normal exam period. By making a special consideration application for the final exam you are declaring yourself available for a resit during the supplementary examination period and will not be eligible for a second special consideration approval based on pre-existing commitments. Please ensure you are familiar with the policy prior to submitting an application. Approved applicants will receive an individual notification one week prior to the exam with the exact date and time of their supplementary examination.

Delivery and Resources

Coronavirus (COVID-19) Update

Any references to on-campus delivery below may no longer be relevant due to COVID-19.

Please check here for updated delivery information: https://ask.mq.edu.au/account/pub/display/unit_status

Classes Mixed Lecture and Tutorial/discussion The timetable for classes can be found on the University web site at: <http://www.timetables.mq.edu.au/>

Required and Recommended Texts and/or Materials **Recommended Text** *Concepts in Thermal Physics* by Blundell & Blundell. This is the same text as used in PHYS2020. It will be used as a frequent reference for most of the unit but will not be followed through in a chapter-by-chapter approach. *Statistical Mechanics* by K Huang, Wiley. This graduate-level text will be used for basic concepts in quantum statistical mechanics, but contains useful material in all topics of the unit.

Additional References *Fundamentals of Statistical and Thermal Physics* by F Reif, McGraw-Hill is a mainstream undergrad textbook *Fundamentals of Statistical and Thermal Physics*, vol 1 by Landau and Lifshitz, any edition, is an advanced undergraduate/ graduate textbook

You can find additional resources, lectures and advice on the page of the Nobel Laureate Gerard 'tHooft

Unit Schedule

Coronavirus (COVID-19) Update

The unit schedule/topics and any references to on-campus delivery below may no longer be relevant due to COVID-19. Please consult [iLearn](#) for latest details, and check here for updated delivery information: https://ask.mq.edu.au/account/pub/display/unit_status

Course structure The topics of the course are roughly as follows week by week: 1. Brief introduction to large numbers, and principles of kinetic theory of gases. The Maxwell Boltzmann distribution. 2. Molecular velocity distribution and collisions. The Boltzmann Equation. Boltzmann's H theorem. 3. Molecular effusion and transport properties - viscosity, conductivity and diffusion. 4. Basic thermodynamic concepts: open/closed/isolated systems, microstates and macrostates, thermodynamic equilibrium and statistical entropy. Counting microstates and statistical temperature, microcanonical ensemble, explanation of equilibrium state. 5. Macroscopic thermodynamics: ideal gas, processes, state variables, internal energy and first law. Heat capacity. Law of Dulong and Petit. Irreversibility, extracting work, and the second law. 6. Entropy. Fundamental relation and Maxwell relations. Thermodynamic potentials. Chemical potential. Cooling real gases, Joule expansion, Joule-Kelvin expansion. Phase diagrams. Van

der Waals gas, isotherms of the vdW gas, vdW gas-liquid transitions, Maxwell construction. 7. Introduction to Statistical Mechanics. Microcanonical, Canonical and Grand Canonical Ensembles, Partition functions. 8. Approximate methods of Statistical Mechanics. 9. Quantum gases. Identical particles, permutation symmetry, spin-statistics theorem, statistics of indistinguishable particles, Fermi vs Bose statistics, ideal Bose gas at high T, BEC, heat capacity of the Bose gas 10. Fermi gases; degenerate Fermi gases. Heat capacity of metals, Fermi pressure, Pauli paramagnetism. 11. Cold atomic and molecular gases. Methods of cooling. Selected applications. 12. Ising model, 2x2 toy model, exchange interactions, Ising Hamiltonian, Mean-field approximation, isotherms of the Ising model, compare vdW gas to Ising system. 13. Phase transitions and critical phenomena. Revision.

Policies and Procedures

Macquarie University policies and procedures are accessible from [Policy Central \(https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central\)](https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central). Students should be aware of the following policies in particular with regard to Learning and Teaching:

- [Academic Appeals Policy](#)
- [Academic Integrity Policy](#)
- [Academic Progression Policy](#)
- [Assessment Policy](#)
- [Fitness to Practice Procedure](#)
- [Grade Appeal Policy](#)
- [Complaint Management Procedure for Students and Members of the Public](#)
- [Special Consideration Policy](#) (**Note:** *The Special Consideration Policy is effective from 4 December 2017 and replaces the Disruption to Studies Policy.*)

Students seeking more policy resources can visit the [Student Policy Gateway \(https://students.mq.edu.au/support/study/student-policy-gateway\)](https://students.mq.edu.au/support/study/student-policy-gateway). It is your one-stop-shop for the key policies you need to know about throughout your undergraduate student journey.

If you would like to see all the policies relevant to Learning and Teaching visit [Policy Central \(https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central\)](https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central).

Student Code of Conduct

Macquarie University students have a responsibility to be familiar with the Student Code of Conduct: <https://students.mq.edu.au/study/getting-started/student-conduct>

Results

Results published on platform other than [eStudent](#), (eg. iLearn, Coursera etc.) or released directly by your Unit Convenor, are not confirmed as they are subject to final approval by the University. Once approved, final results will be sent to your student email address and will be made available in [eStudent](#). For more information visit ask.mq.edu.au or if you are a Global MBA

student contact globalmba.support@mq.edu.au

Student Support

Macquarie University provides a range of support services for students. For details, visit <http://students.mq.edu.au/support/>

Learning Skills

Learning Skills (mq.edu.au/learningskills) provides academic writing resources and study strategies to help you improve your marks and take control of your study.

- [Getting help with your assignment](#)
- [Workshops](#)
- [StudyWise](#)
- [Academic Integrity Module](#)

The Library provides online and face to face support to help you find and use relevant information resources.

- [Subject and Research Guides](#)
- [Ask a Librarian](#)

Student Services and Support

Students with a disability are encouraged to contact the [Disability Service](#) who can provide appropriate help with any issues that arise during their studies.

Student Enquiries

For all student enquiries, visit Student Connect at ask.mq.edu.au

If you are a Global MBA student contact globalmba.support@mq.edu.au

IT Help

For help with University computer systems and technology, visit http://www.mq.edu.au/about_us/offices_and_units/information_technology/help/.

When using the University's IT, you must adhere to the [Acceptable Use of IT Resources Policy](#). The policy applies to all who connect to the MQ network including students.

Changes from Previous Offering

minor changes to unit content and assessment approach have been made.