PHYS7902

Statistical Physics

Session 1, In person-scheduled-weekday, North Ryde 2022

School of Mathematical and Physical Sciences

Contents

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General Information

Unit convenor and teaching staff
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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 ferrormagnetism 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 thermostatistics effectively to other physicists both in writing and orally.

General Assessment Information

Assignments

Weighting: **30%**

Due: Six assignments (three for kinetics & thermodynamics, three for statistical mechanics) given at approximate two week intervals. No late submission, unless agreed before the due time, is allowed.

General points: Problem-solving is an essential aid to understanding the physical concepts and the mathematical tools that must be used in this unit. Regular assignments will be set and the problems marked and returned within two weeks. There will be at six assignments over the semester.

Informal group discussion regarding the assignment problems is encouraged, but students should present their own solutions and should explicitly acknowledge those they have worked with on the assignment. The examinations may contain material related to the assignment work.

Students' individual engagement with assignment questions will be tested through the in-class tutorial presentations.

All marking is performed according to principles of standards-based assessment. Marks are awarded for evidence of correct understanding and analysis of problems. Marks are not normalized to any set distribution.

7000-level students should not need to be reminded that working on problems is an essential part of any physics course. It is only by attempting problems that an understanding of new (and sometimes strange) concepts is obtained. Do not hesitate to seek help if you are having difficulties with the assignment problems.

***Extension Requests*:** students delayed by illness or misadventure should apply for Special Consideration as per the University policy

Tutorial engagement

Weighting: **10%**

Format: weekly seminar sessions

Each tutorial session, several students will present their attempts at either previous assignment questions or tutorial problems [that will be announced at least a week in advance] at the whiteboard.

Students will be assessed on the degree to which they have engaged with the problem, their ability to explain their thinking, and ability to draw on ideas and techniques from the course. The correctness of the final answer is secondary to these other issues.

Each student will be expected to present at the whiteboard on at least 3 to 4 occasions. All students will be expected to engage in the class discussion around these problems.

Grades will be announced periodically during the semester. The grading scheme is as follows:

0 - nil or near nil contribution and engagement 1 - some ability to explain a tutorial problem - reasonably complete explanation of problem 3 - very strong explanation capturing almost all ideas or featuring unexpected/creative insights into the issues.

Two short in-session exams

Weignting: **2x15%**

Due: the exact timing to be set in consultation with the students

Two in-class tests, around weeks 5-7 and 11-13 of 90 minutes duration. Each test will contribute 15% to the final grade. Exact time and allowed material will be determined in consultation with the students.

Final Examination

Weighting: **30%**

Due: **University Examination Period**

The exam will cover the entire content of the unit. Allowed materials will be determined in consultation with the students.

Assessment Tasks

Name	Weighting	Hurdle	Due
Final examination	30%	No	Examination period
Problem-based assignments	30%	No	fortnightly
Two short in-session exams	30%	No	week 6 or 7 and week 12 or 13

Name	Weighting	Hurdle	Due
Tutorial engagement	10%	No	weekly

Final examination

Assessment Type [1]: Examination
Indicative Time on Task [2]: 21 hours
Due: **Examination period**
Weighting: **30%**

Final examination covering all content from the course

On successful completion you will be able to:

- interpret and apply the 0th-3rd laws of thermodynamics, some principal ideas from kinetic theory and the postulates of statistical mechanics
- 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.
- explain the relationship between the different levels of description of thermodynamics and statistical mechanics, and construct models for selected physical systems using these descriptions.
- apply mathematical approaches to solve ideal and practical problems in kinetic theory, thermal and statistical physics.

Problem-based assignments

Assessment Type [1]: Problem set
Indicative Time on Task [2]: 36 hours
Due: **fortnightly**
Weighting: **30%**

Sets of problems based on lecture content

On successful completion you will be able to:

- interpret and apply the 0th-3rd laws of thermodynamics, some principal ideas from kinetic theory and the postulates of statistical mechanics
- 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.
- explain the relationship between the different levels of description of thermodynamics and statistical mechanics, and construct models for selected physical systems using these descriptions.
- apply mathematical approaches to solve ideal and practical problems in kinetic theory, thermal and statistical physics.

Two short in-session exams

Assessment Type [1]: Quiz/Test
Indicative Time on Task [2]: 22 hours
Due: **week 6 or 7 and week 12 or 13**
Weighting: **30%**

Two short tests on content covered up to that point in the session

On successful completion you will be able to:
- interpret and apply the 0th-3rd laws of thermodynamics, some principal ideas from kinetic theory and the postulates of statistical mechanics
- 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.
- explain the relationship between the different levels of description of thermodynamics and statistical mechanics, and construct models for selected physical systems using these descriptions.
- apply mathematical approaches to solve ideal and practical problems in kinetic theory, thermal and statistical physics.

Tutorial engagement

Assessment Type [1]: Participatory task
Indicative Time on Task [2]: 0 hours
Due: **weekly**
Weighting: **10%**

Active engagement and presentation

On successful completion you will be able to:

- present physical arguments in thermostatistics effectively to other physicists both in writing and orally.

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[1] If you need help with your assignment, please contact:

- the academic teaching staff in your unit for guidance in understanding or completing this type of assessment
- the Writing Centre for academic skills support.

[2] Indicative time-on-task is an estimate of the time required for completion of the assessment task and is subject to individual variation

Delivery and Resources

The unit will be offered in person during the scheduled workshop sessions. Assessments will be posted in ilearn or presented in class as appropriate.

Policies and Procedures

Macquarie University policies and procedures are accessible from Policy Central (https://policies.mq.edu.au). 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
- Assessment Procedure
- Complaints Resolution Procedure for Students and Members of the Public
- Special Consideration Policy

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

To find other policies relating to Teaching and Learning, visit Policy Central (https://policies.mq.edu.au) and use the search tool.

Student Code of Conduct

Macquarie University students have a responsibility to be familiar with the Student Code of Conduct: https://students.mq.edu.au/admin/other-resources/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

Academic Integrity

At Macquarie, we believe academic integrity – honesty, respect, trust, responsibility, fairness and courage – is at the core of learning, teaching and research. We recognise that meeting the expectations required to complete your assessments can be challenging. So, we offer you a range of resources and services to help you reach your potential, including free online writing and maths support, academic skills development and wellbeing consultations.

Student Support

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

The Writing Centre

The Writing Centre provides resources to develop your English language proficiency, academic writing, and communication skills.

- Workshops
- Chat with a WriteWISE peer writing leader
- Access StudyWISE
- Upload an assignment to Studiosity
- Complete the 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

Macquarie University offers a range of Student Support Services including:

- IT Support
- Accessibility and disability support with study
- Mental health support
- Safety support to respond to bullying, harassment, sexual harassment and sexual assault
- Social support including information about finances, tenancy and legal issues

Student Enquiries

Got a question? Ask us via AskMQ, or contact Service Connect.

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.