PHYS7902

Statistical Physics

Session 1, Weekday attendance, North Ryde 2021

Archive (Pre-2022) - Department of Physics and Astronomy

Contents

Notice

As part of Phase 3 of our return to campus plan, most units will now run tutorials, seminars and other small group activities on campus, and most will keep an online version available to those students unable to return or those who choose to continue their studies online.

To check the availability of face-to-face activities for your unit, please go to timetable viewer. To check detailed information on unit assessments visit your unit's iLearn space or consult your unit convenor.

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: **25%**

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: Given the importance we place on assignments as an aid to learning we expect assignments to be submitted on time. In turn, we undertake to return your assignments (provided they were submitted on time), marked and with feedback within two weeks of their due date. Extensions will only be considered if requested with valid reasons **prior to the due date**.

If for any reason a student is unable to submit an assignment by the due date, the student should contact the relevant staff member as soon as possible, explain the situation, and request an extension.

Tutorial engagement

Due: **Weekly** Weighting: **10%**

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

Due: the exact timing to be set in consultation with the students Weighting: **50%**

Two in-class tests, around weeks 5-7 and 11-13 of 90 minutes duration. Each test will contribute 25% to the final grade. Exact time and allowed material will be determined in consultation with the students.

Final Examination

Due: **University Examination Period** Weighting: **15%**

Exact time and form will be determined in consultation with the students.

Assessment Tasks

Name	Weighting	Hurdle	Due
Final examination	15%	No	Examination period
Tutorial engagement	10%	No	weekly during classes
Two short in-session exams	50%	No	week 7 and week 12
Problem-based assignments	25%	No	fortnightly

Final examination

Assessment Type [1]: Examination
Indicative Time on Task [2]: 21 hours
Due: **Examination period**
Weighting: **15%**

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.

Tutorial engagement

Assessment Type [1]: Participatory task
Indicative Time on Task [2]: 0 hours
Due: **weekly during classes**
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.

Two short in-session exams

Assessment Type [1]: Quiz/Test
Indicative Time on Task [2]: 22 hours
Due: **week 7 and week 12**
Weighting: **50%**

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.

Problem-based assignments

Assessment Type [1]: Problem set
Indicative Time on Task [2]: 36 hours
Due: **fortnightly**
Weighting: **25%**

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.

[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

Classes

Mixed Lecture and Tutorial/discussion. All activities are in -person and scheduled on campus.

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 PHYS2202. 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

Statistical 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 t'Hooft

Technology Used and Required

Unit Web Page

This unit will be administered through iLearn at http://ilearn.mq.edu.au/course/view.php?id=12028. Please check this site regularly for lecture and extension material available for downloading and look out for announcements. We will run one or more discussion fora through the iLearn

page for both technical physics and administrative issues. Staff will ignore emails and discussion questions about issues which are already explained in this document or which have been covered in the announcements and discussion features of the iLearn page.

Teaching and Learning Strategy

The theoretical aspects of this unit are taught in lectures and tutorials with fortnightly assignments to strengthen the understanding of the material. The theoretical material is heavily mathematical in nature, and often abstract, and true understanding can only be achieved through testing and refining understanding through problem solving.

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
- Grade Appeal Policy
- Complaint Management 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

Student Support

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

dents.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.