# PHYS7902

## Statistical Physics

Session 1, In person-scheduled-weekday, North Ryde 2024

*School of Mathematical and Physical Sciences*

## Contents

# 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

## Requirements to Pass this Unit

To pass this unit you must achieve a total mark equal to or greater than 50%. There are no hurdles.

## Late Assessment Submission Penalty

Unless a Special Consideration request has been submitted and approved, a 5% penalty (of the total possible mark) will be applied each day a written assessment is not submitted, up until the 7th day (including weekends). After the 7th day, a grade of 0 will be awarded even if the assessment is submitted. Submission time for all written assessments is set at 11:55 pm. A 1-hour grace period is provided to students who experience a technical concern. For late submission of time-sensitive tasks, such as scheduled tests/exams, students need to submit an application for Special Consideration. Assessments where Late Submissions will be accepted: • Assignments – YES, Standard Late Penalty applies • Mid semester Tests – No, unless Special Consideration is granted • Examination – NO, unless Special Consideration is granted

# Assessment Tasks

| Name | Weighting | Hurdle | Due |
|---|---|---|---|
| Problem-based assignments | 30% | No | weeks 2, 4, 6, 8, 10, 12 |
| Two short in-session exams | 30% | No | weeks 7 and 12 to be confirmed |
| Tutorial engagement | 10% | No | weekly during tutorials |
| Final examination | 30% | No | final examination period |

## Problem-based assignments

Assessment Type [1]: Problem set
Indicative Time on Task [2]: 36 hours
Due: **weeks 2, 4, 6, 8, 10, 12**
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: **weeks 7 and 12 to be confirmed**
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 during tutorials**
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.

## Final examination

Assessment Type [1]: Examination
Indicative Time on Task [2]: 21 hours
Due: **final 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.

[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

There are two 2-hour workshops each week. Three hours each week will be allocated for lectures, and these will allow plenty of opportunity for questions and discussion. Lecture notes will be available on ilearn and the recommended texts are also available from the library.

We will designate one hour each week for tutorials and we will post tutorial questions each week to be presented during the tutorials by students to the class on a whiteboard or similar. The tutorial participation mark is allocated for these presentations and class discussions. Lectures and Tutorials begin in week 1.

We will communicate with you via your student email and through the announcements or discussion forum on ilearn.

## Special Consideration

The Special Consideration Policy aims to support students who have been impacted by short-term circumstances or events that are serious, unavoidable and significantly disruptive, and which may affect their performance in assessment. If you experience circumstances or events that affect your ability to complete the written assessments in this unit on time, please inform the convenor and submit a Special Consideration request through ask.mq.edu.au.

COVID: please refer to the Coronavirus infection page on the Macquarie website: https://www.mq.edu.au/about/coronavirus-faqs. Please check this page regularly in case the information and requirements change during semester. If there are any changes to this unit in relation to COVID, these will be communicated via iLearn.

## Communication

We will communicate with you via your university email or through announcements on iLearn. Queries to convenors can either be placed on the iLearn discussion board, raised in class, or sent to your lecturers by email from your university email address.

# Unit Schedule

Week 1-3 Danny Intro to classical mechanics and quantum

Week 4-6 Judith - Thermodynamics

Week 7 Revision and mid sem test

Week 8-10 Judith Kinetic theory

Week 11-13 Danny Statistical mechanics

# 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 Advocacy provides independent advice on MQ policies, procedures, and processes

## 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.

# Changes from Previous Offering

Following student feedback on the 2023 offering, we have done some re-ordering of material to provide a better introduction to new quantum and statistics concepts.

Unit information based on version 2024.02 of the Handbook