PHYS7901

Mathematical Methods in Physics

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

School of Mathematical and Physical Sciences

Contents

General Information

Unit convenor and teaching staff
Ji Li
ji.li@mq.edu.au

Michael Steel
michael.steel@mq.edu.au

Credit points
10

Prerequisites
Admission to MRes

Corequisites

Co-badged status

Unit description
This unit covers topics in mathematical physics including: differential equations and group theory. The aim is to develop effective problem solving strategies, and where possible, the examples will be taken from the physical sciences. In the first topic the primary focus is on ordinary differential equations covering topics from first order equations and how to classify and solve them, through to higher order equations and more general techniques such as reduction of order, Laplace transforms, Green functions and series solutions. The second topic covers discrete groups and continuous Lie groups and Lie algebras. Group representations are introduced with the examples from Abelian and non-Abelian groups. Irreducible representations, unitary representations, Shur's Lemma, and orthogonality relations are covered in the context of discrete groups. Compact and non-compact Lie groups and their generating Lie algebras are presented with several examples making the connection between symmetries and conservation laws, e.g. space-time symmetries and the Poincare group.

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: apply analytic methods for solving linear differential equations.

ULO2: describe and use numerical methods for solving ordinary or partial differential equations.

ULO3: employ discrete groups, continuous Lie groups and Lie algebras, and representation theory.

ULO4: infer discrete and continuous symmetries from the properties of physical systems.

ULO5: explain the relations between symmetries and conservation laws.

ULO6: analyse differential equations and group theory using Mathematica.

General Assessment Information

Planning your time

The 'estimated time on task' for each assessment item is an estimate of the *additional* time needed to complete each assessment outside of all scheduled learning activities. These estimates assume that you actively engage with all scheduled learning activities *and* spend an additional 31 hours of self-led study during the session.

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.

Requirements to Pass the Unit

There are no hurdle tasks specified in this unit. Consequently, the requirement to pass is to obtain an overall mark of at least 50% across the three assessment components. While the assignments only contribute 20% to the final grade, completing them carefully is a key part of your preparation for the two examinations.

Late Assessment Submission Penalty

Late submission of assignments will be accepted under the standard University policy: Unless a Special Consideration request has been submitted and approved, a 5% penalty (of the total possible mark of the task) will be applied for each day a written assignment or laboratory report is not submitted, up until the 7th day (including weekends and holidays). After the 7th day, a grade of **0** will be awarded even if the assessment is submitted. The submission time for all uploaded assessments is 11:55 pm. A 1-hour grace period will be provided to students who experience a technical concern.

For any late submission of time-sensitive tasks, such as scheduled tests/exams, performance assessments/presentations, and/or scheduled practical assessments/labs, please apply for Special Consideration.

Assignment schedule

There will be five assignments of equal weight, released approximately fortnightly and due approximately 10-12 days after posting. MRes year 1 can be busy and we understand there may be an undesirable confluence of assignments from multiple units at times. If this occurs, please contact the lecturer *as early as possible* and we will be happy to negotiate a change to the due date for the whole class. Requests are less likely to be granted if they are made at the last minute.

Special consideration

The Special Consideration Policy aims to support students who have been impacted by shortterm 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 con- venor and submit a Special Consideration request through ask.mq.edu.au.

Assessment Tasks

Name	Weighting	Hurdle	Due
Problem-based assignments	20%	No	Issued approximately fortnightly.
Final examination	40%	No	As scheduled centrally
Midsession exam	40%	No	To be scheduled during Week 8 commencing 8 April

Problem-based assignments

Assessment Type [1]: Problem set
Indicative Time on Task [2]: 32 hours
Due: **Issued approximately fortnightly.**
Weighting: **20%**

Sets of problems based on lecture content

On successful completion you will be able to:

- apply analytic methods for solving linear differential equations.
- describe and use numerical methods for solving ordinary or partial differential equations.

- employ discrete groups, continuous Lie groups and Lie algebras, and representation theory.
- infer discrete and continuous symmetries from the properties of physical systems.
- explain the relations between symmetries and conservation laws.
- analyse differential equations and group theory using Mathematica.

Final examination

Assessment Type [1]: Examination
Indicative Time on Task [2]: 21 hours
Due: **As scheduled centrally**
Weighting: **40%**

Final examination covering all content from the course.

On successful completion you will be able to:

- apply analytic methods for solving linear differential equations.
- describe and use numerical methods for solving ordinary or partial differential equations.
- employ discrete groups, continuous Lie groups and Lie algebras, and representation theory.
- infer discrete and continuous symmetries from the properties of physical systems.
- explain the relations between symmetries and conservation laws.

Midsession exam

Assessment Type [1]: Quiz/Test
Indicative Time on Task [2]: 11 hours
Due: **To be scheduled during Week 8 commencing 8 April**
Weighting: **40%**

Exam on content from the first half of the unit

On successful completion you will be able to:

- apply analytic methods for solving linear differential equations.
- describe and use numerical methods for solving ordinary or partial differential equations.

[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

There is one two hour lecture each week. There is one two hour SGTA each week beginning in week 1.

Both classes will run in a highly interactive mode and you should not consider the lecture as less important to attend than the SGTA.

There will be no Echo360 recording of either class.

Texts

There is no specified textbook for the unit. A detailed set of notes will be provided for the first half and other reading will be suggested but is not required.

Technology

We will make frequent use of python for simulation and integration of differential equations. You may use your own computer or the SoMaPS PC laboratory in 12WW-209.

Communication with staff

Outside class, please communicate with staff primarily by email from your university email address. We encourage you to get in touch and arrange a private meeting during office hours on any topics that may be causing you difficulty.

Unit Schedule

The first 7 weeks will focus on the development of analytical mechanics and the numerical solution of dynamical systems that we derive.

The remaining part of the unit will focus on introductory of mathematics of discrete and continuous groups.

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 connect.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 the Service Connect Portal, 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

Change of staff

Prof. Steel is joining the unit in 2024 replacing Prof. Dominic Berry. He has taught the relevant material on and off for over a decade.

Change of content

To make the content more interesting and appealing to a wider range of MReas students in physics and astronomy, the first half of the unit is adopting a new focus on the topic of Advanced Classical Mechanics, including the Lagrangian and Hamiltonian formalisms.

The content will still involve substantial material on derivation and solution of differential equations, but with a greater emphasis on more generally applicable numerical techniques.

Change of delivery style

The classical mechancs will be taught in quasi-flipped mode, with significant prepatory reading required for each class, which will involve frequent discussion, problem solving, and team work.

Unit information based on version 2024.01R of the Handbook