PHYS7901
Mathematical Methods in Physics
Session 1, In person-scheduled-weekday, North Ryde 2024
School of Mathematical and Physical Sciences

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General Information

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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 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.

Assessment Tasks

<table>
<thead>
<tr>
<th>Name</th>
<th>Weighting</th>
<th>Hurdle</th>
<th>Due</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem-based</td>
<td>20%</td>
<td>No</td>
<td>Issued approximately fortnightly.</td>
</tr>
<tr>
<td>assignments</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final examination</td>
<td>40%</td>
<td>No</td>
<td>As scheduled centrally</td>
</tr>
<tr>
<td>Midsession exam</td>
<td>40%</td>
<td>No</td>
<td>To be scheduled during Week 8 commencing 8 April</td>
</tr>
</tbody>
</table>

Problem-based assignments

Assessment Type: Problem set
Indicative Time on Task: 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: Examination
Indicative Time on Task: 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: Quiz/Test
Indicative Time on Task: 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:
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
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/](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 mechanics will be taught in quasi-flipped mode, with significant preparatory 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](https://unitguides.mq.edu.au/unit_offerings/164884/unit_guide/print)