# ACE Network Subject Information Guide

## Introduction to Nonlinear PDEs

## Semester 2, 2023

**Administration and contact details**

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|---|---|
| **Host department** | **School of Physical and Mathematical Sciences** |
| **Host institution** | **The University of Newcastle** |
| | |
| **Name of lecturer** | **Michael Meylan** |
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| **Homepage** | **https://www.newcastle.edu.au/profile/mike-meylan** |
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| **Name of honours coordinator** | **Lachlan Rogers** |
| **Phone number** | **02) 40557574** |
| **Email address** | **lachlan.rogers@newcastle.edu.au** |
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| **Name of masters coordinator** | **As above** |
| **Phone number** | **As above** |
| **Email address** | **As above** |

**Subject details**

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|---|---|
| **Handbook entry URL** | TBD |
| **Subject homepage URL** | TBD |
| **Honours student hand-out URL** | TBD |
| | |
| **Teaching period (start and end date):** | **17/07/2023- 20/10/2023** |
| **Exam period (start and end date):** | **30/10/2023 – 3/11/2023** |
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| **Contact hours per week:** | **2** |
| **ACE enrolment closure date:** | **TBA** |
| **Lecture day(s) and time(s):** | **Thurs 2-4PM AEST** |
| | |
| **Description of electronic access arrangements for students (for example, LMS)** | **To be decided later**<br>**I used Dropbox to share the course materials in the past. I will see if there is a better alternative.** |

**Subject content**

1. **Subject content description**

This course is an introduction to nonlinear partial differential equations, focusing on nonlinear wave phenomena. We will consider applications from physics, ocean engineering, chemical engineering, civil engineering and biology. The underlying partial differential equations will be derived and the properties of the solutions will be investigated. Simulations of the PDEs will be obtained using MATLAB.

2. **Week-by-week topic overview**

1. Revision of the method of characteristics for linear partial differential equation.
2. Traffic waves, solution using characteristics and shock dynamics
3. Nonlinear shallow water waves or compressible gas dynamic waves. Solution by characteristics, the dam break problem, shock dynamics, hydraulic jumps and shallow water bores.
4. KdV (Korteweg-De Vries) equation. Travelling wave solutions, solitary and cnoidal waves.
5. Numerical solution of the KdV using the split-step method and computation of the soliton-soliton interaction.
6. Conservation laws for the KdV and Miura's transformation.
7. Introduction to the IST (Inverse Scattering transformation).
8. Properties of the Linear Schrodinger equation
9. The connection between the KdV and the Schrodinger equation.
10. Example calculations for the KdV and IST
11. Reaction-Diffusion systems.
12. Burgers equation.

3. **Assumed prerequisite knowledge and capabilities**

A course in ordinary differential equations is essential. Knowledge of separation of variables for linear partial differential equations is helpful but not essential.

4. **Learning outcomes and objectives**

- Understand the different approaches to solving nonlinear Partial differential equations.
- Implement split step spectral methods.
- Analyse travelling wave solutions using phase plane analysis.

Solve nonlinear PDEs analytically.

**AQF specific Program Learning Outcomes and Learning Outcome Descriptors (if available):**

| AQF Program Learning Outcomes addressed in this subject | Associated AQF Learning Outcome Descriptors for this subject |
|---|---|
| Insert Program Learning Outcome here | Choose from list below |
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**Learning Outcome Descriptors at AQF Level 8**

**Knowledge**

K1: coherent and advanced knowledge of the underlying principles and concepts in one or more disciplines

K2: knowledge of research principles and methods

**Skills**

S1: cognitive skills to review, analyse, consolidate and synthesise knowledge to identify and provide solutions to complex problem with intellectual independence

S2: cognitive and technical skills to demonstrate a broad understanding of a body of knowledge and theoretical concepts with advanced understanding in some areas

S3: cognitive skills to exercise critical thinking and judgement in developing new understanding

S4: technical skills to design and use in a research project

S5: communication skills to present clear and coherent exposition of knowledge and ideas to a variety of audiences

**Application of Knowledge and Skills**

A1: with initiative and judgement in professional practice and/or scholarship

A2: to adapt knowledge and skills in diverse contexts

A3: with responsibility and accountability for own learning and practice and in collaboration with others within broad parameters

A4: to plan and execute project work and/or a piece of research and scholarship with some independence

## 5. Learning resources

Detailed course notes are available at
http://www.wikiwaves.org/Category:Nonlinear_PDE%27s_Course

In addition the following books will be useful

- *Wave Motion*, by Billingham and King.
- *Solitons and the Inverse Scattering Transform*, by Ablowitz and Segur
- *Solitons, Nonlinear Evolution Equations and Inverse Scattering*, by Ablowtiz and Clarkson
- *Spectral methods in MATLAB*, by Trefethen

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6. **Assessment**

| **Exam/assignment/classwork breakdown** | | | | | |
|---|---|---|---|---|---|
| **Exam** | 50% | **Assignment** | 50% | **Class work** | 0 % |
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| **Assignment due dates** | | **01/09/2023** | **01/10/2023** | **01/11/2023** | |
| | | | | | |
| **Approximate exam date** | | | | **3**0/10/2023 | |

## Institution honours program details

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|---|---|
| **Weight of subject in total honours assessment at host department** | 12.5% |
| **Thesis/subject split at host department** | 37.5% thesis, 62.5% subjects |
| **Honours grade ranges at host department** | |
| **H1** | 85-100 |
| **H2a** | 75-84 |
| **H2b** | 65-74 |
| **H3** | 50-64 |

## Institution masters program details

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|---|---|
| **Weight of subject in total masters assessment at host department** | NA |
| **Thesis/subject split at host department** | NA |
| **Masters grade ranges at host department** | |
| **H1** | NA |
| **H2a** | NA |
| **H2b** | NA |
| **H3** | NA |