



# MATH331

## Waves

S1 Day 2015

*Dept of Mathematics*

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### **Disclaimer**

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## General Information

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Credit points

3

Prerequisites

MATH235 and (MATH232 or MATH236)

Corequisites

Co-badged status

Unit description

This unit introduces the theory of waves by a systematic study of the underlying partial differential equations. Waves involve the transfer, without bulk motion, of both energy and information. Fundamental properties of waves are first examined in the simplest one-dimensional setting. The treatment is then broadened to two-dimensional and three-dimensional waves, particularly for acoustic and electromagnetic waves. Resonators and waveguides provide some examples of how waves behave in confined regions. In contrast, the scattering and diffraction of waves by obstacles in free space carries information about the scatterer itself; this is the basis of many imaging technologies.

## 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:

Develop a good understanding and demonstrate knowledge of the basic methods and concepts of theory of wave equations and partial differential equations.

Demonstrate the ability to construct logical, clearly presented and justified mathematical arguments especially in the context of the theory of wave equations. Be able to express yourself clearly and logically in writing in this context.

Present a broad outline of the scope of theory of wave equations and their roles in mathematical modelling of physical phenomena.

Be able to apply the principles, concepts, and techniques learned in this unit to solve practical and abstract problems.

Demonstrate appropriate interpretation of information communicated in mathematical form. Be able to understand what is being said in mathematical expressions and be able to formulate ideas using mathematical form.

Ethical application of mathematical approaches to solving problems and appropriately reference and acknowledge sources in a mathematical context.

Be able to work effectively, responsibly and safely in an individual or team context.

## Assessment Tasks

| Name                                     | Weighting | Due                           |
|--|-----------|-------------------------------|
| <u><a href="#">Eight assignments</a></u> | 20%       | TBA                           |
| <u><a href="#">Test</a></u>              | 20%       | TBA                           |
| <u><a href="#">Final examination</a></u> | 60%       | University Examination Period |

### Eight assignments

Due: **TBA**

Weighting: **20%**

On successful completion you will be able to:

- Develop a good understanding and demonstrate knowledge of the basic methods and concepts of theory of wave equations and partial differential equations.
- Demonstrate the ability to construct logical, clearly presented and justified mathematical arguments especially in the context of the theory of wave equations. Be able to express

yourself clearly and logically in writing in this context.

- Present a broad outline of the scope of theory of wave equations and their roles in mathematical modelling of physical phenomena.
- Be able to apply the principles, concepts, and techniques learned in this unit to solve practical and abstract problems.
- Demonstrate appropriate interpretation of information communicated in mathematical form. Be able to understand what is being said in mathematical expressions and be able to formulate ideas using mathematical form.
- Ethical application of mathematical approaches to solving problems and appropriately reference and acknowledge sources in a mathematical context.
- Be able to work effectively, responsibly and safely in an individual or team context.

## Test

Due: **TBA**

Weighting: **20%**

### Test

On successful completion you will be able to:

- Develop a good understanding and demonstrate knowledge of the basic methods and concepts of theory of wave equations and partial differential equations.
- Demonstrate the ability to construct logical, clearly presented and justified mathematical arguments especially in the context of the theory of wave equations. Be able to express yourself clearly and logically in writing in this context.
- Be able to apply the principles, concepts, and techniques learned in this unit to solve practical and abstract problems.
- Demonstrate appropriate interpretation of information communicated in mathematical form. Be able to understand what is being said in mathematical expressions and be able to formulate ideas using mathematical form.
- Be able to work effectively, responsibly and safely in an individual or team context.

## Final examination

Due: **University Examination Period**

Weighting: **60%**

Final examination

On successful completion you will be able to:

- Develop a good understanding and demonstrate knowledge of the basic methods and concepts of theory of wave equations and partial differential equations.
- Demonstrate the ability to construct logical, clearly presented and justified mathematical arguments especially in the context of the theory of wave equations. Be able to express yourself clearly and logically in writing in this context.
- Present a broad outline of the scope of theory of wave equations and their roles in mathematical modelling of physical phenomena.
- Be able to apply the principles, concepts, and techniques learned in this unit to solve practical and abstract problems.
- Demonstrate appropriate interpretation of information communicated in mathematical form. Be able to understand what is being said in mathematical expressions and be able to formulate ideas using mathematical form.
- Ethical application of mathematical approaches to solving problems and appropriately reference and acknowledge sources in a mathematical context.
- Be able to work effectively, responsibly and safely in an individual or team context.

## Delivery and Resources

### Classes

**Lectures:** you should attend two hours of each lecture stream each week, making a total of four hours.

### Required and Recommended Texts and/or Materials

No single textbook is entirely satisfactory for MATH331. The following texts provide useful references for various sections of the course:

- Roger Knobel, *An Introduction to the Mathematical Theory of Waves*, American Mathematical Society, 1999 (QA927.K963/1999)
- Walter A. Strauss, *Partial Differential Equations: An Introduction*, John Wiley and Sons, 1992. (QA374.S86/1992)
- A.N. Tikhonov & A.A. Samarskii, *Equations of Mathematical Physics*, Oxford University Press (also reprinted by Dover) (QA401.T512/1963)
- J. Billingham & A. C. King, *Wave Motion*, Cambridge University Press, 2000.
- R. Harrington, *Time Harmonic Electromagnetic Fields*, McGraw-Hill, 1961 (QA403.H24)
- Charles A. Coulson, *Waves* (2nd ed. revised by A. Jeffrey), London (QA927.C65/1977)

### Technology Used and Required

Students are expected to have access to an internet enabled computer with a web browser and

Adobe Reader software. Several areas of the university provide wireless access for portable computers. There are computers for student use in the Library and in the [Numeracy Centre \(C5A 255\)](#).

**Difficulties with your home computer or internet connection do not constitute a reasonable excuse for lateness of, or failure to submit, assessment tasks.**

## Unit Schedule

| Week | Techniques                                | Methods   |
|------|---|---|
| 1    | 1-D wave equation,<br>D'Alembert solution | Introduction;<br>PDEs and waves                         |
| 2    | Semi-infinite string                      | Travelling and dispersive waves                         |
| 3    | Standing waves on a string                | The KdV equation, solitons                              |
| 4    | Fourier series                            | The KdV equation, solitons                              |
| 5    | Fourier series                            | Acoustic waves (2,3-D);<br>models and conservation laws |
| 6    | Resonators: rectangular boxes             | Reflection; the planar waveguide                        |
| 7    | Bessel functions                          | Plane and spherical waves                               |
| 8    | Bessel functions                          | Scattering: hard, soft obstacles                        |
| 9    | Waveguides - circular                     | Scattering: boundary and radiation conditions           |
| 10   | Waveguides - rectangular                  | Scattering: integral representations                    |
| 11   | Acoustic scattering from a cylinder       | Introduction to electromagnetic (EM) waves              |
| 12   | Acoustic scattering from a cylinder       | Introduction to electromagnetic (EM) waves              |
| 13   | Revision                                  | Revision  |

## Policies and Procedures

Macquarie University policies and procedures are accessible from [Policy Central](#). Students should be aware of the following policies in particular with regard to Learning and Teaching:

Academic Honesty Policy [http://mq.edu.au/policy/docs/academic\\_honesty/policy.html](http://mq.edu.au/policy/docs/academic_honesty/policy.html)

Assessment Policy <http://mq.edu.au/policy/docs/assessment/policy.html>

Grading Policy <http://mq.edu.au/policy/docs/grading/policy.html>

Grade Appeal Policy <http://mq.edu.au/policy/docs/gradeappeal/policy.html>

Grievance Management Policy [http://mq.edu.au/policy/docs/grievance\\_management/policy.html](http://mq.edu.au/policy/docs/grievance_management/policy.html)

Disruption to Studies Policy [http://www.mq.edu.au/policy/docs/disruption\\_studies/policy.html](http://www.mq.edu.au/policy/docs/disruption_studies/policy.html) *The*

*Disruption to Studies Policy is effective from March 3 2014 and replaces the Special Consideration Policy.*

In addition, a number of other policies can be found in the [Learning and Teaching Category](#) of Policy Central.

## Student Code of Conduct

Macquarie University students have a responsibility to be familiar with the Student Code of Conduct: [https://students.mq.edu.au/support/student\\_conduct/](https://students.mq.edu.au/support/student_conduct/)

## Results

Results shown in *iLearn*, 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](http://ask.mq.edu.au).

## Student Support

Macquarie University provides a range of support services for students. For details, visit <http://students.mq.edu.au/support/>

## Learning Skills

Learning Skills ([mq.edu.au/learningskills](http://mq.edu.au/learningskills)) provides academic writing resources and study strategies to improve your marks and take control of your study.

- [Workshops](#)
- [StudyWise](#)
- [Academic Integrity Module for Students](#)
- [Ask a Learning Adviser](#)

## 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](http://ask.mq.edu.au)

## IT Help

For help with University computer systems and technology, visit <http://informatics.mq.edu.au/help/>.

When using the University's IT, you must adhere to the [Acceptable Use Policy](#). The policy applies to all who connect to the MQ network including students.

## Graduate Capabilities

### Creative and Innovative

Our graduates will also be capable of creative thinking and of creating knowledge. They will be imaginative and open to experience and capable of innovation at work and in the community. We want them to be engaged in applying their critical, creative thinking.

This graduate capability is supported by:

#### Learning outcomes

- Develop a good understanding and demonstrate knowledge of the basic methods and concepts of theory of wave equations and partial differential equations.
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- Be able to work effectively, responsibly and safely in an individual or team context.

#### Assessment tasks

- Eight assignments
- Test
- Final examination

### Capable of Professional and Personal Judgement and Initiative

We want our graduates to have emotional intelligence and sound interpersonal skills and to demonstrate discernment and common sense in their professional and personal judgement. They will exercise initiative as needed. They will be capable of risk assessment, and be able to handle ambiguity and complexity, enabling them to be adaptable in diverse and changing environments.

This graduate capability is supported by:

#### Learning outcomes

- Demonstrate the ability to construct logical, clearly presented and justified mathematical arguments especially in the context of the theory of wave equations. Be able to express yourself clearly and logically in writing in this context.
- Ethical application of mathematical approaches to solving problems and appropriately reference and acknowledge sources in a mathematical context.
- Be able to work effectively, responsibly and safely in an individual or team context.



## Assessment tasks

- Test
- Final examination

## Commitment to Continuous Learning

Our graduates will have enquiring minds and a literate curiosity which will lead them to pursue knowledge for its own sake. They will continue to pursue learning in their careers and as they participate in the world. They will be capable of reflecting on their experiences and relationships with others and the environment, learning from them, and growing - personally, professionally and socially.

This graduate capability is supported by:

### Learning outcomes

- Develop a good understanding and demonstrate knowledge of the basic methods and concepts of theory of wave equations and partial differential equations.
- Be able to apply the principles, concepts, and techniques learned in this unit to solve practical and abstract problems.
- Demonstrate appropriate interpretation of information communicated in mathematical form. Be able to understand what is being said in mathematical expressions and be able to formulate ideas using mathematical form.

## Assessment tasks

- Eight assignments
- Final examination

## Discipline Specific Knowledge and Skills

Our graduates will take with them the intellectual development, depth and breadth of knowledge, scholarly understanding, and specific subject content in their chosen fields to make them competent and confident in their subject or profession. They will be able to demonstrate, where relevant, professional technical competence and meet professional standards. They will be able to articulate the structure of knowledge of their discipline, be able to adapt discipline-specific knowledge to novel situations, and be able to contribute from their discipline to inter-disciplinary solutions to problems.

This graduate capability is supported by:

### Learning outcomes

- Develop a good understanding and demonstrate knowledge of the basic methods and concepts of theory of wave equations and partial differential equations.
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arguments especially in the context of the theory of wave equations. Be able to express yourself clearly and logically in writing in this context.

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## Assessment tasks

- Eight assignments
- Test
- Final examination

## Critical, Analytical and Integrative Thinking

We want our graduates to be capable of reasoning, questioning and analysing, and to integrate and synthesise learning and knowledge from a range of sources and environments; to be able to critique constraints, assumptions and limitations; to be able to think independently and systemically in relation to scholarly activity, in the workplace, and in the world. We want them to have a level of scientific and information technology literacy.

This graduate capability is supported by:

## Learning outcomes

- Develop a good understanding and demonstrate knowledge of the basic methods and concepts of theory of wave equations and partial differential equations.
- Demonstrate the ability to construct logical, clearly presented and justified mathematical arguments especially in the context of the theory of wave equations. Be able to express yourself clearly and logically in writing in this context.
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- Be able to apply the principles, concepts, and techniques learned in this unit to solve practical and abstract problems.
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## Assessment tasks

- Eight assignments
- Test
- Final examination

## Problem Solving and Research Capability

Our graduates should be capable of researching; of analysing, and interpreting and assessing data and information in various forms; of drawing connections across fields of knowledge; and they should be able to relate their knowledge to complex situations at work or in the world, in order to diagnose and solve problems. We want them to have the confidence to take the initiative in doing so, within an awareness of their own limitations.

This graduate capability is supported by:

## Learning outcomes

- Develop a good understanding and demonstrate knowledge of the basic methods and concepts of theory of wave equations and partial differential equations.
- Demonstrate the ability to construct logical, clearly presented and justified mathematical arguments especially in the context of the theory of wave equations. Be able to express yourself clearly and logically in writing in this context.
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## Assessment tasks

- Eight assignments
- Test
- Final examination

## Effective Communication

We want to develop in our students the ability to communicate and convey their views in forms effective with different audiences. We want our graduates to take with them the capability to read, listen, question, gather and evaluate information resources in a variety of formats, assess, write clearly, speak effectively, and to use visual communication and communication technologies as appropriate.

This graduate capability is supported by:

## Learning outcomes

- Demonstrate the ability to construct logical, clearly presented and justified mathematical arguments especially in the context of the theory of wave equations. Be able to express yourself clearly and logically in writing in this context.
- Present a broad outline of the scope of theory of wave equations and their roles in mathematical modelling of physical phenomena.
- Demonstrate appropriate interpretation of information communicated in mathematical form. Be able to understand what is being said in mathematical expressions and be able to formulate ideas using mathematical form.
- Ethical application of mathematical approaches to solving problems and appropriately reference and acknowledge sources in a mathematical context.
- Be able to work effectively, responsibly and safely in an individual or team context.

## Assessment tasks

- Eight assignments
- Test
- Final examination

## Engaged and Ethical Local and Global citizens

As local citizens our graduates will be aware of indigenous perspectives and of the nation's historical context. They will be engaged with the challenges of contemporary society and with knowledge and ideas. We want our graduates to have respect for diversity, to be open-minded, sensitive to others and inclusive, and to be open to other cultures and perspectives: they should have a level of cultural literacy. Our graduates should be aware of disadvantage and social justice, and be willing to participate to help create a wiser and better society.

This graduate capability is supported by:

## Learning outcomes

- Ethical application of mathematical approaches to solving problems and appropriately reference and acknowledge sources in a mathematical context.
- Be able to work effectively, responsibly and safely in an individual or team context.

## Assessment tasks

- Eight assignments
- Final examination

## Socially and Environmentally Active and Responsible

We want our graduates to be aware of and have respect for self and others; to be able to work with others as a leader and a team player; to have a sense of connectedness with others and country; and to have a sense of mutual obligation. Our graduates should be informed and active participants in moving society towards sustainability.

This graduate capability is supported by:

### Learning outcomes

- Ethical application of mathematical approaches to solving problems and appropriately reference and acknowledge sources in a mathematical context.
- Be able to work effectively, responsibly and safely in an individual or team context.

### Assessment task

- Test