MATH338

Algebra IIIB

S2 Day 2014

Mathematics

Contents

General Information

Unit convenor and teaching staff
Lecturer
Gerry Myerson
gerry.myerson@mq.edu.au
Contact via x8952
E7A 202
By appointment

Lecturer
Paul Smith
paul.smith@mq.edu.au
Contact via paul.smith@mq.edu.au
E7A 216

Credit points
3

Prerequisites

Corequisites
MATH337

Co-badged status

Unit description
This unit further develops the theory of algebraic structures commenced in MATH337, and involves the study of a selection of topics in field theory as well as a study of algorithms used in the application of linear algebra to the practical computational solution of real-world problems. The field theory strand develops the basic theory, including the notion of irreducibility of polynomials, simple, algebraic and transcendental extensions, and the tower law. The ideas of group theory studied in MATH337 are then applied to the study of field extensions via the notion of automorphisms, culminating in the study of the Galois correspondence theorem. The numerical linear algebra strand focuses on the study of large matrices and the use of matrix decomposition techniques appropriate to the computation of approximate solutions of the kinds of differential equations with specified boundary conditions that commonly arise in problems in science and engineering.

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:

Demonstrate a well-developed knowledge of the principles, concepts, and techniques of Galois Theory and Numerical Linear Algebra.
Demonstrate an understanding of the breadth of Galois Theory and Numerical Linear Algebra, their multi-disciplinary role, and the way they contribute to the development of the mathematical sciences.
Construct logical, clearly presented and justified mathematical arguments incorporating deductive reasoning as applied to Galois Theory and Numerical Linear Algebra.
Formulate and model practical and abstract problems in Galois Theory and Numerical Linear Algebra in mathematical terms using a variety of methods from algebra, analysis, and applied mathematics.
Apply mathematical principles, concepts, techniques, and technology to solve practical and abstract problems in Galois Theory and Numerical Linear Algebra.
Appropriately interpret information concerning Galois Theory and Numerical Linear Algebra communicated in a wide variety of forms.
Appropriately present ideas, information, reasoning, and conclusions concerning Galois Theory and Numerical Linear Algebra in forms tailored to the needs of diverse audiences.
Work effectively, responsibly and safely in an individual context.

Assessment Tasks

Name	Weighting	Due
Ten assignments	40%	Weeks 4 through 13
MATLAB computation	0%	weeks 6-13
Final examination	60%	University Examination Period

Ten assignments

Due: **Weeks 4 through 13**
Weighting: **40%**

Assignments.

On successful completion you will be able to:

- Demonstrate a well-developed knowledge of the principles, concepts, and techniques of Galois Theory and Numerical Linear Algebra.
- Demonstrate an understanding of the breadth of Galois Theory and Numerical Linear Algebra, their multi-disciplinary role, and the way they contribute to the development of the mathematical sciences.
- Construct logical, clearly presented and justified mathematical arguments incorporating deductive reasoning as applied to Galois Theory and Numerical Linear Algebra.
- Formulate and model practical and abstract problems in Galois Theory and Numerical Linear Algebra in mathematical terms using a variety of methods from algebra, analysis, and applied mathematics.
- Apply mathematical principles, concepts, techniques, and technology to solve practical and abstract problems in Galois Theory and Numerical Linear Algebra.
- Appropriately interpret information concerning Galois Theory and Numerical Linear Algebra communicated in a wide variety of forms.
- Appropriately present ideas, information, reasoning, and conclusions concerning Galois Theory and Numerical Linear Algebra in forms tailored to the needs of diverse audiences.
- Work effectively, responsibly and safely in an individual context.

MATLAB computation

Due: **weeks 6-13**
Weighting: **0%**

included as integral part of numerical linear algebra assessments

On successful completion you will be able to:

- Formulate and model practical and abstract problems in Galois Theory and Numerical Linear Algebra in mathematical terms using a variety of methods from algebra, analysis, and applied mathematics.
- Apply mathematical principles, concepts, techniques, and technology to solve practical and abstract problems in Galois Theory and Numerical Linear Algebra.
- Appropriately interpret information concerning Galois Theory and Numerical Linear Algebra communicated in a wide variety of forms.
- Appropriately present ideas, information, reasoning, and conclusions concerning Galois Theory and Numerical Linear Algebra in forms tailored to the needs of diverse audiences.
- Work effectively, responsibly and safely in an individual context.

Final examination

Due: **University Examination Period**
Weighting: **60%**

-

On successful completion you will be able to:

- Demonstrate a well-developed knowledge of the principles, concepts, and techniques of Galois Theory and Numerical Linear Algebra.
- Construct logical, clearly presented and justified mathematical arguments incorporating deductive reasoning as applied to Galois Theory and Numerical Linear Algebra.
- Formulate and model practical and abstract problems in Galois Theory and Numerical Linear Algebra in mathematical terms using a variety of methods from algebra, analysis, and applied mathematics.
- Apply mathematical principles, concepts, techniques, and technology to solve practical and abstract problems in Galois Theory and Numerical Linear Algebra.
- Appropriately interpret information concerning Galois Theory and Numerical Linear Algebra communicated in a wide variety of forms.
- Appropriately present ideas, information, reasoning, and conclusions concerning Galois Theory and Numerical Linear Algebra in forms tailored to the needs of diverse audiences.
- Work effectively, responsibly and safely in an individual 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

The notes for the Galois Theory part of MATH338 are available for download. Clickhere. The numerical linear algebra part of MATH338 is strongly based on the material in Lloyd Trefethen and David Bau, *Numerical Linear Algebra*, SIAM, 1977.

ADDITIONAL TEXTS

Galois Theory

- Ian Stewart, *Galois Theory* Chapman and Hall 2nd Edition or 3rd Edition 1989. We will cover Chapters 1 - 4 and 7 - 14.
- John A. Beachy, *Introductory Lectures on Rings and Modules* Cambridge 1999. We will

cover Chapters 1 - 3, excluding the starred sections.

- Harold M. Edwards, *Galois Theory* Springer, 1984, Graduate Texts in Mathematics 101 (written in the spirit of "Read the masters!", there is a definite attempt to expose Galois' original ideas).
- Emil Artin, *Galois Theory* Notre Dame Mathematical Lectures 2, 1959 (the pithy work of a master - very thin).
- Francis Borceux and George Janelidze, *Galois Theories* Cambridge Studies in Advanced Mathematics 72, 2001 (the early sections are appropriate for this unit; the keen student can then find how Galois' ideas have developed in recent times).
- Tom Petsinis, *The French Mathematician, A Novel* Penguin, 1997 (non-technical novel written in the first person as Galois, sets the historical stage for Galois' work; a fun read of a sad tale!).

Numerical Linear Algebra

- Gilbert Strang, *Linear Algebra and its Applications* Brooks/Cole, 1988 (contains useful supporting material, but too elementary for this course).
- Gene Golub and Charles van Loan, *Matrix Computations* John Hopkins University Press, 1983 (a more advanced reference).

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	Monday - mostly Galois Theory	Tuesday - mostly Numerical Linear Algebra	TASK DUE
1	Background to Galois Theory	Prime Polynomials (Gal)	
2	Motivation for Numerical Linear Algebra (NLA)	Motivation (ctd.)	
3	Ruler and Compass Constructions	Impossible Constructions (Gal)	
4	The Quadratic and the Cubic	Unitary matrices; norms for vectors and matrices	Assignment 1
5	The Singular Value Decomposition (NLA)	The Singular Value Decomposition	Assignment 2

6	Galois Groups	Introduction to MATLAB	Assignment 3
7	Solvability by Radicals	QR Decomposition and Householder reflectors	Assignment 4
	MID-SEMESTER BREAK		
8	Solvability by Radicals	QR Decomposition and Householder reflectors	Assignment 5
9	Examples of Galois Groups	Least squares	Assignment 6
10	Examples of Galois Groups	LU Decomposition; pivoting and condition number	Assignment 7
11	Finite Fields	LU Decomposition; pivoting and condition number	Assignment 8
12	Finite Fields	Ill-conditioned systems and regularisation	Assignment 9
13	Revision	Revision	Assignment 10

Learning and Teaching Activities

Lectures

four lectures per week

assessment tasks

see assessment tasks

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

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

Disruption to Studies Policy 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/

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) 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

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

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 a well-developed knowledge of the principles, concepts, and techniques of Galois Theory and Numerical Linear Algebra.
- Demonstrate an understanding of the breadth of Galois Theory and Numerical Linear Algebra, their multi-disciplinary role, and the way they contribute to the development of the mathematical sciences.
- Construct logical, clearly presented and justified mathematical arguments incorporating deductive reasoning as applied to Galois Theory and Numerical Linear Algebra.
- Formulate and model practical and abstract problems in Galois Theory and Numerical Linear Algebra in mathematical terms using a variety of methods from algebra, analysis, and applied mathematics.
- Apply mathematical principles, concepts, techniques, and technology to solve practical and abstract problems in Galois Theory and Numerical Linear Algebra.
- Appropriately present ideas, information, reasoning, and conclusions concerning Galois Theory and Numerical Linear Algebra in forms tailored to the needs of diverse audiences.
- Work effectively, responsibly and safely in an individual context.

Assessment tasks

- Ten assignments
- MATLAB computation
- Final examination

Learning and teaching activities

- see assessment tasks

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

- Demonstrate a well-developed knowledge of the principles, concepts, and techniques of Galois Theory and Numerical Linear Algebra.
- Demonstrate an understanding of the breadth of Galois Theory and Numerical Linear

Algebra, their multi-disciplinary role, and the way they contribute to the development of the mathematical sciences.
- Construct logical, clearly presented and justified mathematical arguments incorporating deductive reasoning as applied to Galois Theory and Numerical Linear Algebra.

Assessment tasks

- Ten assignments
- MATLAB computation
- Final examination

Learning and teaching activities

- see assessment tasks

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

- Demonstrate a well-developed knowledge of the principles, concepts, and techniques of Galois Theory and Numerical Linear Algebra.
- Demonstrate an understanding of the breadth of Galois Theory and Numerical Linear Algebra, their multi-disciplinary role, and the way they contribute to the development of the mathematical sciences.
- Construct logical, clearly presented and justified mathematical arguments incorporating deductive reasoning as applied to Galois Theory and Numerical Linear Algebra.
- Formulate and model practical and abstract problems in Galois Theory and Numerical Linear Algebra in mathematical terms using a variety of methods from algebra, analysis, and applied mathematics.
- Apply mathematical principles, concepts, techniques, and technology to solve practical and abstract problems in Galois Theory and Numerical Linear Algebra.

Assessment tasks

- Ten assignments

- MATLAB computation
- Final examination

Learning and teaching activities

- see assessment tasks

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

- Demonstrate a well-developed knowledge of the principles, concepts, and techniques of Galois Theory and Numerical Linear Algebra.
- Demonstrate an understanding of the breadth of Galois Theory and Numerical Linear Algebra, their multi-disciplinary role, and the way they contribute to the development of the mathematical sciences.
- Construct logical, clearly presented and justified mathematical arguments incorporating deductive reasoning as applied to Galois Theory and Numerical Linear Algebra.
- Formulate and model practical and abstract problems in Galois Theory and Numerical Linear Algebra in mathematical terms using a variety of methods from algebra, analysis, and applied mathematics.
- Apply mathematical principles, concepts, techniques, and technology to solve practical and abstract problems in Galois Theory and Numerical Linear Algebra.

Assessment tasks

- Ten assignments
- MATLAB computation
- Final examination

Learning and teaching activities

- see assessment tasks

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

- Demonstrate a well-developed knowledge of the principles, concepts, and techniques of Galois Theory and Numerical Linear Algebra.
- Demonstrate an understanding of the breadth of Galois Theory and Numerical Linear Algebra, their multi-disciplinary role, and the way they contribute to the development of the mathematical sciences.
- Construct logical, clearly presented and justified mathematical arguments incorporating deductive reasoning as applied to Galois Theory and Numerical Linear Algebra.

Assessment tasks

- Ten assignments
- MATLAB computation
- Final examination

Learning and teaching activities

- see assessment tasks

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

- Demonstrate a well-developed knowledge of the principles, concepts, and techniques of Galois Theory and Numerical Linear Algebra.
- Demonstrate an understanding of the breadth of Galois Theory and Numerical Linear Algebra, their multi-disciplinary role, and the way they contribute to the development of the mathematical sciences.
- Construct logical, clearly presented and justified mathematical arguments incorporating deductive reasoning as applied to Galois Theory and Numerical Linear Algebra.
- Formulate and model practical and abstract problems in Galois Theory and Numerical Linear Algebra in mathematical terms using a variety of methods from algebra, analysis, and applied mathematics.

- Apply mathematical principles, concepts, techniques, and technology to solve practical and abstract problems in Galois Theory and Numerical Linear Algebra.

Assessment tasks

- Ten assignments
- MATLAB computation
- Final examination

Learning and teaching activities

- see assessment tasks

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

- Appropriately interpret information concerning Galois Theory and Numerical Linear Algebra communicated in a wide variety of forms.
- Appropriately present ideas, information, reasoning, and conclusions concerning Galois Theory and Numerical Linear Algebra in forms tailored to the needs of diverse audiences.

Assessment tasks

- Ten assignments
- MATLAB computation
- Final examination

Learning and teaching activities

- see assessment tasks

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

- Demonstrate a well-developed knowledge of the principles, concepts, and techniques of Galois Theory and Numerical Linear Algebra.
- Demonstrate an understanding of the breadth of Galois Theory and Numerical Linear Algebra, their multi-disciplinary role, and the way they contribute to the development of the mathematical sciences.
- Construct logical, clearly presented and justified mathematical arguments incorporating deductive reasoning as applied to Galois Theory and Numerical Linear Algebra.
- Appropriately interpret information concerning Galois Theory and Numerical Linear Algebra communicated in a wide variety of forms.
- Appropriately present ideas, information, reasoning, and conclusions concerning Galois Theory and Numerical Linear Algebra in forms tailored to the needs of diverse audiences.
- Work effectively, responsibly and safely in an individual context.

Assessment tasks

- Ten assignments
- MATLAB computation
- Final examination

Learning and teaching activities

- see assessment tasks

Extra requirements

Satisfactory performance on supervised assessment tasks, such as tests and the final exam, is necessary to pass this unit. If there is a significant difference between a student's marks on supervised assessment tasks and on unsupervised assessment tasks, the scaling of these tasks may be adjusted when determining the final grade, to reflect more appropriately that student's performance on supervised tasks.