Unit Guide

ECE3093
Optimisation, Estimation and Numerical Methods

Mode of delivery	On-campus
Workload requirements	3 hours of lectures, one 2-hour support class and 7 hours of private study per week (on average)
Prerequisites	ECE2011, ENG2092
Chief examiner	Professor Kate Smith-Miles
Unit coordinator:	Professor Kate Smith-Miles
Campus:	Clayton
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Email:	Kate.Smith-Miles@monash.edu
Office:	Room 443, Building 28
Office hours:	***Thursdays 9-10am and Friday 1-2pm*** (or at other times by appointment via email)
Teaching Team	Professor Kate Smith-Miles (see above) – Clayton Dr. Daniel Tokarev – Clayton Daniel.Tokarev@monash.edu Alan Couchman – Clayton Alan.Couchman@monash.edu Dr. Nader Kamrani – (Campus coordinator Malaysia) Nader.Kamrani@eng.monash.edu.my

Semester One
2013

ACADEMIC OVERVIEW

Learning Outcomes

The unit builds upon knowledge acquired in ENG1060, ENG1091, ENG2092, and ECE2011. On completing this unit, students will have learned advanced techniques in working with matrices efficiently and reliably, and their use in solving problems frequently arising in engineering applications such as solving linear systems, solving systems of differential equations, modelling control systems, and studying stability in dynamical systems. The singular value decomposition technique, and principal component analysis, provide a powerful tool for data compression, noise filtering, and greatly simplify the calculations for many numerical tasks. Curve fitting for estimation, and optimization tools add to the toolkit of techniques students will have to tackle a range of practical engineering problems. The students will also have learnt how to work with discrete and continuous random variables and some important distributions, random vectors and their covariance matrices, calculating best linear predictors, modelling using random sequences and stochastic processes in continuous time, autocovariance functions, spectral density and linear filters, ARMA models, finding best linear predictors for stationary processes, transfer functions and stochastic integrals. They will have applied these techniques to forecasting in time series, filtering in signal processing and circuit analysis.

In particular students will be able to:

- express a written mathematical argument clearly, using appropriate wording along with mathematical symbols and notation;
- demonstrate understanding of linear algebra methods, and extend upon their foundation in Gaussian Elimination to generate the matrix decomposition method LU;
- understand the Spectral Theorem and the properties of matrices that can be diagonalised;
- appreciate the advantaged of diagonalising a matrix for ease of calculation of inverses, powers, exponentials of a matrix;
- understand the concepts of bases, orthogonality, projections, and how to construct orthogonal bases from generalized eigenvectors;
- understand how to derive eigenvalue-revealing decompositions for matrices with particular properties;
- understand the singular value decomposition (SVD) method, and its broad applicability to any matrix;
- appreciate the applications of SVD to principal component analysis and data reduction and compression (particularly for images), noise filtering, and easy calculation of matrix properties such as rank, condition number, and the pseudo-inverse;
- demonstrate understanding of suitable numerical methods for the reliable calculation of eigenvalues and eigenvectors, and the SVD;
- appreciate the breadth of optimization problems and solution approaches, and understand some basic methods for constrained and unconstrained optimization, as well as modern heuristic methods for solving combinatorial optimization problems;
- appreciate the use of random variables for modelling and understand their distributions and corresponding densities and PMFs and how to calculate variance, moments and expectation, as well as apply inequalities;
- understand random vectors including univariate and multivariate Gaussian vectors, how to calculate joint and marginal distributions, mixed moments and covariance, understand dependence and independence, covariance as inner product and covariance matrices and linear prediction;
- understand random sequences, stationarity, autocovariance functions and spectral densities, white noise, linear filter and transfer functions;
- understand ARMA processes, the existence of stationary and causal solutions, how to calculate spectral density, how to check invertibility of ARMA models and find autocovariance functions of ARMA and apply Yule-Walker method to find the autocovariance function of the stationary solution;
- understand modelling Time Series using Yule-Walker Estimators, Maximum Likelihood Estimators and applications of modelling.

The final unit content for ECE3093 is determined by the material covered during lectures and support classes – including all material on the problem sheets and any published lecture notes on Moodle.

UNIT SCHEDULE

The table below shows the planned outline schedule of lectures and assessment for ECE3093 but from time to time it may be necessary to adjust this slightly for operational reasons. *Please listen for any announcements in class (and/or check the announcements on Moodle regularly).*

Lecture	**Week** (Commencing)	**Topic**
	Part I	Topic 1: Linear Algebra
Lecture 1	**Week 1** (4 Mar)	***Introduction and matrix LU decomposition***
Lecture 2		***Review of linear algebra: vectors, matrices, linear systems***
Lecture 3		***Matrix operations and properties***
Support class 1		
		Topic 2: Eigenvalue-Revealing Decompositions
Lecture 4	**Week 2** (11 March)	***Eigenanalysis and Diagonalisation***
Lecture 5		***Applications of Diagonalisation***
Lecture 6		***Principal Component Analysis and Eigenfaces***
Support class 2		
Lecture 7	**Week 3** (18 March)	***Triangularisation: Generalised eigenvectors and Jordon Canonical Form***
Lecture 8		***Orthogonalisation and Schur Decomposition***
		Topic 3: Singular Value Decomposition
Lecture 9		***Singular Value Decomposition (SVD)***
Support Class 3		
Lecture 10	**Week 4** (25 March)	***Applications of SVD to data compression and noise filtering***
Lecture 11		***Matrix Properties via SVD***
Lecture 12		***GOOD FRIDAY (no lecture)***
Support class 4		
MID-SEMESTER BREAK		
Lecture 13	**Week 5** (8 April)	***Least-squares Approximations and Curve Fitting***
		Topic 4: Numerical Methods for Eigenanalysis
Lecture 14		***Computing the SVD: QR decomposition***
Lecture 15		***Numerical Methods for Eigenanalysis***
Support class 5		
		Topic 5: Optimisation

Lecture 16	**Week 6** (15 April)	***Overview of Optimisation***
Lecture 17		***Unconstrained Optimisation***
Lecture 18		***Constrained Optimisation***
Support class 6		
Part II Topic 1: Introduction to Time Series and Elements of Probability Theory and Random Vectors		
Lecture 19	**Week 7** (22 April)	
	ANZAC DAY	***No lecture***
Lecture 20		***Examples of Time Series and Objectives of Time Series Analysis***
Support class 7		***Trend, Seasonality and Noise***
Lecture 21	**Week 8** (29 April)	***Random variables, distributions, densities and PMFs***
Lecture 22		***Variance and Random Vectors***
Lecture 23		***Random Vectors and Covariance***
Support Class 8		
Lecture 24	**Week 9** (6 May)	***Covariance and Independence***
Lecture 25		***Random Vectors, Expectation Vector and Covariance Matrix***
Lecture 26		***Covariance Matrices and Gaussian Distributions***
Support Class 9		
Topic 2: Random Sequences and Prediction		
Lecture 27	**Week 10** (13 May)	***Gaussian vectors and affine transport***
Lecture 28		***Spectral decomposition and prediction***
Lecture 29		***Prediction (continued)***
Support Class 10		
Lecture 30	**Week 11** (20 May)	***Random sequences, autoregressive processes and stationarity***
Lecture 31		***Autocovariance function, spectral density, inversion and linear processes***
Lecture 32		***Linear processes and ARMA processes***
Support Class 11		
Topic 3: Modelling ARMA Processes		
Lecture 33	**Week 12** (27 May)	***Prediction with AR and ARMA models***
Lecture 34		***Modelling Time Series: Yule-Walker Estimators***
Lecture 35		***Maximum Likelihood Estimators***
STUDY WEEK		

Assessment summary

Due	Submission at	Activity	Value %
End of week 2, by midnight Sunday	Online quiz on Moodle	Quiz based on week 1 lecture material	1%
End of week 4, by midnight Sunday	Online quiz on Moodle	Quiz based on weeks 2 and 3 lecture material	2%
Mid-Semester Break			
Start of week 5, by 10am Monday	Assignment box, ground floor, building 28 (Clayton students); Malaysian students please check with lecturer	Assignment 1, part a	5%
End of week 6, by 5pm Friday	Assignment box, ground floor, building 28 (Clayton students); Malaysian students please check with lecturer	Assignment 1, part b	5%
End of week 6, by midnight Sunday	Online quiz on Moodle	Quiz based on weeks 4 and 5 lecture material	2%
End of week 8, by 5pm Friday	Assignment box, ground floor, building 28 (Clayton students); Malaysian students please check with lecturer	Assignment 2, part a	3%
End of week 8, by midnight Sunday	Online quiz on Moodle	Quiz based on week 7 lecture material	1%
End of week 10, by 5pm Friday	Assignment box, ground floor, building 28 (Clayton students); Malaysian students please check with lecturer	Assignment 2, part b	3%
End of week 10, by midnight Sunday	Online quiz on Moodle	Quiz based on weeks 8 and 9 lecture material	2%
End of week 12, by 5pm Friday	Assignment box, ground floor, building 28 (Clayton students); Malaysian students please check with lecturer	Assignment 2, part c	4%
End of week 12, by midnight Sunday	Online quiz on Moodle	Quiz based on weeks 10 and 11 lecture material	2%
		Total continuous assessment	**30%**
		Final examination (3 hours)	**70%**
		Total assessment	**100%**

Teaching approach

ECE3093 is taught using a combination of lectures and support classes. Casual assistance is also available through consultation times.

At the Clayton campus there will be 35 one-hour lectures in ECE3093 (Good Friday lecture will not occur), held weekly on Tuesdays at 2pm (in E7), Thursdays at 8am (in E7) and Fridays at 12noon (in E7). Some recorded information from lectures is available through the Monash University Lectures Online (http://mulo.monash.edu) but it only includes the visual information projected on the computer screen (and may fail due to occasional technical problems). Students should aim to attend every lecture in order to gain full advantage of the teaching and use the recordings as a fallback to check on any points that they missed, and to assist revision.

All students are also expected to attend one two-hour support class per week from the first week of semester (commencing Monday 4th March). The intention of the support classes is to introduce you to, and help you to master, the theory described in lectures as well a range of practice exercises. The week 1 support class will focus on revising pre-requisite knowledge from ENG1091. An

attendance roll will be taken at the end of each support class and may be used to inform academic progress considerations, if requested by the Faculty of Engineering.

There will be three different sessions of support classes each week at Clayton (and two in Malaysia), and you will be assigned to a particular class through the *Allocate+* online system. If you have not already submitted your choice of preferences for particular ECE3093 support classes, this should be done no later than the first week of semester through *Allocate+* at http://allocate.cc.monash.edu.au/. If your circumstances change and the initial allocation is no longer appropriate, for example if you altered your enrolment and there is now a clash, you should contact the Faculty of Engineering office for advice on changing between support classes – but no later than the end of the second week of semester. Attendance is taken at all support classes, so you may attend any support classes in a given week, subject to a limit on the total of attendees. You have priority to be in the class to which you have been allocated in *Allocate+*.

Please note that there is an assumption of about 7 hours per week on average of private study, consisting of assignment work, lecture revision, and additional researching and reading. Note that this is an average, and might depend on the level of your previous skills and confidence in mathematics and/or the particular stage of semester. It is strongly recommended that you establish a regular study routine that is broadly consistent with the above, or you may soon find yourself falling behind in the lecture material, with not enough time remaining in the semester to catch up. In particular, it is *strongly recommended* that you take at least an hour per lecture going back over the material covered – and preferably before the following lecture, as the teaching of mathematics lectures usually assumes an understanding of material described in earlier lectures.

ASSESSMENT REQUIREMENTS

Assessment tasks

Details of the assignment requirements will be made available during the semester, once relevant content has been covered in lectures.

It is acknowledged that students can assist their learning by discussing difficulties and helping each other to solve problems. However, there are limits to which they should assist each other in assessed work without it being considered to be 'inappropriate collusion' or cheating. It is therefore expected that all students should complete all final assessed work for ECE3093 individually, and in their own words. Among other things, markers will be looking specifically for instances where the wording of submitted work is very similar, and where there are identical errors in algebraic working or logic. *Instances of suspected cheating will be dealt with seriously, in accordance with Faculty and University policies.*

The chief examiner reserves the right to moderate the assessments at the end of the semester, to ensure suitable distribution of grades.

Examination

Work assessed during semester determines 30% of the final unit mark for ECE3093, with the remaining 70% based on results from the three-hour final examination, to be held in the university examination period at the end of semester.

Note that calculators and summary sheets *are not permitted in the final examination.* However, a collection of some relevant formulae will be attached to the exam paper.

To achieve a pass in the unit students must achieve a mark of 45% in each of these two components (continuous assessment and examination).

Assignment submission

In accordance with school and university policy, all assignments must include a signed cover sheet. The cover sheet can be downloaded via the My.Monash portal at http://my.monash.edu.au

under the heading ‘Learning and teaching tools’. Hard copies of cover sheets are also often available from the third floor of the mathematics building (outside the lift).

While every care is taken, it is strongly recommended that you make a copy of your assignment for your records before it is submitted - for example on a scanner or photocopier.

Extensions and penalties

Late assignments will normally be penalised at 10% of the mark per calendar day (1% per two-hour period, including over weekends) until the time when solutions are published on Moodle, after which a zero mark is awarded. Students with a valid reason for late submission must provide ***the unit coordinator*** with originals (and a copy) of appropriate documentation as soon as practicable after the normal deadline. ***Support class leaders are not authorized to approve extensions to deadlines.***

Returning marked work

Marked assignments are normally returned to you at your support class. Your marks will also be posted on the Grade Book in Moodle at around the same time and you should check these regularly. If any of them have been entered incorrectly please query them with your tutor *in a timely manner*.

If you are unable to collect your work at the usual time, please ask your tutor at the next support class. Any uncollected work *after the end of semester* can be collected from the unit coordinator.

Resubmission of assignments

Students are not permitted to resubmit assignments for ECE3093. Efforts are made to ensure that marks for assignments are awarded as consistently as possible across the various support classes and markers.

If you believe that an error has been made in the marking of any assessment, for example missed working or a mistake in the addition, you should discuss that with your tutor initially. If you are not satisfied with their response you should contact the unit coordinator to arrange a meeting.

Feedback

Our feedback to you

Feedback is provided to ECE3093 students in a variety of ways during the semester, to assist their learning and help them identify the issues for which they may need to seek further assistance. This includes through:

- individual and group consultations with staff during the weekly support classes;
- individual assistance through the Mathematics Learning Centre;
- written feedback on the ten homework and quiz tasks submitted at some support classes, usually marked and returned at the next class, and with sample solutions available on the Moodle site;
- written feedback on the two assignments, usually marked and returned within 2 weeks, and with sample solutions on the Moodle site;
- encouraging students to ask questions in or after lectures;
- individual or group consultations at the lecturers’ weekly consultation hours, or at by appointment via email;
- prompt responses to queries on the ECE3093 discussion groups on Moodle.

In particular, it is also strongly recommended that you take full advantage of the assistance and feedback provided in the support classes for ECE3093. The tutor, Alan Couchman, is a very experienced teacher for this unit, and is highly regarded by previous students. Unit evaluations from past semesters have confirmed that students highly valued Alan’s support classes to facilitate their learning.

If you are having any sort of difficulties consult the appropriate staff as soon as possible after you become aware of them – not just in relation to understanding particular units, but also in your

personal life. See the 'Engineering Survival Guide' for information on some of the support services available within the university.

Your feedback to us

Monash University is committed to excellence in education and regularly seeks feedback from students, employers and staff. One of the key formal ways students have to provide feedback is through SETU, Student Evaluation of Teacher and Unit. The University's student evaluation policy requires that every unit is evaluated each year. Students are strongly encouraged to complete the surveys. The feedback is anonymous and provides the Faculty with evidence of aspects that students are satisfied and areas for improvement.

For more information on the University's educational strategy, and on student evaluations, see:

http://www.monash.edu.au/about/monash-directions/directions.html

http://www.policy.monash.edu/policy-bank/academic/education/quality/student-evaluation-policy.html

Previous student evaluations

If you wish to view how previous students rated this unit, please go to

https://emuapps.monash.edu.au/unitevaluations/index.jsp

Immediate feedback

Feedback is welcome at any time throughout the semester. Please use email to send it to the unit coordinator, or discuss in person. You may also post comments on the appropriate discussion group for ECE3093 on Moodle provided they are not defamatory or in any way breach the university's acceptable use of IT policy.

You may wish to use the open ended questions in the unit evaluation to provide written feedback on your experience of this unit and whether it has been helpful to you.

Recommended resources

Prescribed text

There is no prescribed textbook for ECE3093 due to the breadth of topics covered. A collection of excellent articles is provided on the Moodle site to supplement the lecture notes.

Lecture notes

Copies of the lecture slides used for ECE3093 will be made available on Moodle, typically on by the Friday before the next week's lectures. Please print these and bring to lectures for annotation.

Support Class Materials

Resources required for support classes will be made available on Moodle in the Support Classes folder.

Past Exam Papers

As a means of revision, you might also try questions on some previous examination papers. Copies of a sample examination paper and some past papers will be made available via Moodle towards the end of semester, with some sample solutions provided in some cases. If you have queries or difficulties with these, please raise them with the lecturer or in your support class.

Additional study resources may also be made available through Moodle from time to time.

Engineers Australia stage 1 competencies

The Engineers Australia Policy on Accreditation of Professional Engineering Programs requires that all programs ensure that their engineering graduates develop to a substantial degree the stage 1 competencies. Listed below are the activities in this unit that will help you to achieve these competencies. Note: that not all stage 1 competencies are relevant to each unit.

Stage 1 competencies	Activities used in this unit to develop stage 1 competencies
PE1.1 Knowledge of science and engineering fundamentals	The lectures, teaching materials and support-class activities develop and assess students' knowledge of mathematics and analysis techniques. Relevance to engineering applications is reinforced. Working from first principles is emphasised.
PE1.2 In-depth technical competence in at least one engineering discipline	
PE1.3 Techniques and resources	Mathematical models of simple applications to engineering are introduced, analysed and interpreted in the lectures, prescribed text, problem sets and written assignments.
PE1.4 General knowledge	
PE2.1 Ability to undertake problem identification, formulation, and solution	Problem identification, simplification and solution are an essential part of all problem sets, support class activities, written assignments and quizzes. Students are encouraged to explain their mathematical reasoning in words, not just as symbols.
PE2.2 Understanding of social, cultural, global, and environmental responsibilities and the need to employ principles of sustainable development	
PE2.3 Ability to utilise a systems approach to complex problems and to design and operational performance	Wherever appropriate, students are trained in lectures to understand the relative advantages and disadvantages of different mathematical techniques.
PE2.4 Proficiency in engineering design	
PE2.5 Ability to conduct an engineering project	Students develop an understanding of mathematical models in lectures and many support-class activities.
PE2.6 Understanding of the business environment	
PE3.1 Ability to communicate effectively, with the engineering team and with the community at large	Students are trained in support classes to write their explanations in a manner that is understandable to their colleagues. This is assessed in assignments.
PE3.2 Ability to manage information and documentation	Students are encouraged in both lectures and support classes to express themselves clearly, and draw clear diagrams that illustrate their reasoning.
PE3.3 Capacity for creativity and innovation	In lectures students are encouraged to develop their own approaches to problems from first principles. Support classes and assignments are used to provide individual feedback on such approaches.
PE3.4 Understanding of professional and ethical responsibilities, and commitment to them	
PE3.5 Ability to function effectively as an individual and in multidisciplinary and multicultural teams, as a team leader or manager as well as an effective team member	
PE3.6 Capacity for lifelong learning and professional development PE3.7 Professional attitudes	Students are provided with links to supplementary materials on the unit website and encouraged to use other resources that assist their learning.

OTHER INFORMATION

Policies

Monash has educational policies, procedures and guidelines, which are designed to ensure that staff and students are aware of the University's academic standards, and to provide advice on how they might uphold them. You can find Monash's Education Policies at: www.policy.monash.edu.au/policy-bank/academic/education/index.html

Key educational policies include:

- Plagiarism;
- Assessment in Coursework Programs;
- Special Consideration;
- Grading Scale;
- Discipline: Student Policy;
- Academic Calendar and Semesters;
- Orientation and Transition; and
- Academic and Administrative Complaints and Grievances Policy.

Graduate Attributes Policy

http://www.policy.monash.edu/policy-bank/academic/education/management/monashgraduate-attributes-policy.html

Student Services

The University provides many different kinds of services to help you gain the most from your studies.Contact your tutor if you need advice and see the range of services available at www.monash.edu.au/students

Monash University Library

The Monash University Library provides a range of services, resources and programs that enable you to save time and be more effective in your learning and research. Go to www.lib.monash.edu.au or the library tab in my.monash portal for more information.

Disability Liaison Unit

Students who have a disability or medical condition are welcome to contact the Disability Liaison Unit to discuss academic support services. Disability Liaison Officers (DLOs) visit all Victorian campuses on a regular basis.

- Website: www.monash.edu/equity-diversity/disability/index.html
- Telephone: 03 9905 5704 to book an appointment with a DLO;
- Email: dlu@monash.edu
- Drop In: Equity and Diversity Centre, Level 1, Building 55, Clayton Campus.See also the 'Engineering Survival Guide' for information on some of the support services available within the University.