ELEC4621
Advanced Digital Signal Processing
Course Outline – Semester 1, 2015

Never Stand Still | Faculty of Engineering | School of Electrical Engineering and Telecommunications

Course Staff

Course Convener:	Prof. David Taubman, Room EE303, d.taubman@unsw.edu.au
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Consultations: You are encouraged to ask questions on the course material, after the lecture class times in the first instance, rather than via email. Lecturer consultation times will be advised during lectures. ALL email enquiries should be made from your student email address with ELEC4621 in the subject line, otherwise they will not be answered.

Keeping Informed: Announcements may be made during classes, via email (to your student email address) and/or via the subject web-site – this subject uses the School of EE&T's subjects repository at http://subjects.ee.unsw.edu.au/~elec4621. Please note that you will be deemed to have received this information, so you should take careful note of all announcements.

Course Summary

Contact Hours

The course consists of 3 hours of lectures, a 1-hour tutorial, and a 3-hour laboratory session every two weeks.

Lectures	Day	Time	Location	Weeks
	Monday	3pm – 5pm	Red Centre M010	w1-w12 inclusive
	Thursday	12noon – 1pm	CLB 1	w1-w12 inclusive
Tutorials	Tuesday	12noon – 1pm	EE214	w3-w13 odd only
Labs	Tuesday	12noon – 3pm	EE214	w2-w12 even only
	Thursday	9am – 12noon (*tent*)	EE214	w2-w12 even only

Context and Aims

This subject builds upon the material introduced in Elec3104, focusing exclusively on digital signal processing techniques. The following topics are covered:

- Sampling, aliasing and the relationship between discrete and continuous signals
- Review of Fourier transforms, the Z-transform, FIR and IIR filters, and oscillators
- Filter implementation techniques, structures and numerical round-off effects
- Filter design techniques
- Auto-correlation, cross-correlation, and power spectrum estimation techniques
- Linear prediction
- Wiener filters, LMS adaptive filters, and applications.
- Multi-rate signal processing and subband transforms.
- Time-frequency analysis, the short time Fourier transform, and wavelet transforms (time permitting)

Indicative Program

Week	Begins	Lab/Tut	Lecture Topic(s)
1	Mar 2		Convolution, FT, DTFT, sampling, discrete vs. continuous time
2	Mar 9	Lab 1	Z-transforms, filters and oscillators
3	Mar 16	Tut 1	Filter implementation structures & techniques
4	Mar 23	Lab 2 **	Filter implementation: quantization effects + DFT
5	Mar 30	Tut 2	Filter Design Techniques
Mid-Session Break			
6	Apr 13	Lab 3 **	Filter Design Techniques continued **In-class test #1 (Thursday)**
7	Apr 20	Tut 3 *test feedback*	Statistics and power spectrum estimation
8	Apr 27	Lab 4 **	Linear Prediction
9	May 4	Tut 4	Wiener and adaptive filtering
10	May 11	Lab 5 **	Multi-rate Processing and Subband transforms
11	May 18	Tut 5	Subband transforms continued
12	May 25	Lab 6 **	Brief intro to time-frequency analysis **In-class test #2 (Thursday)**
13	Jun 1	*test feedback and revision*	*No lectures*

Notes: ** means that a laboratory assessment is due

Assessment

Laboratory Projects	25%
In-class Test-1 *(exemption granted only with medical certificate)*	10%
In-class Test-2 *(exemption granted only with medical certificate)*	10%
Final Exam (3 hours)	55%

Course Details

Credits

This is a 6 UoC course and the expected workload is 10–12 hours per week throughout the 13 week semester.

Relationship to Other Courses

This is a 4th year professional elective course in the School of Electrical Engineering and Telecommunications.

Pre-requisites and Assumed Knowledge

The pre-requisite for this course is ELEC3104, Digital Signal Processing. It is also essential that you are familiary with elementary signal processing concepts and linear algebra before this course is attempted. It is further assumed that students have a working knowledge of Matlab, which is used in the laboratory projects.

Following Courses

The course is not a pre-requisite for any other courses offered by the School of EE&T. However, students undertaking postgraduate studies involving signal processing should find that this course provides an excellent preparation for such further study. As an undergraduate professional elective, this course provides a solid foundation for a surprisingly wide range of professional engineering design and development activities.

Learning outcomes

After successful completion of this course, the student should:

1. Have a more thorough understanding of the relationship between time and frequency domain interpretations and implementations of signal processing algorithms;
2. Understand and be able to implement adaptive signal processing algorithms based on second order statistics; and
3. Be familiar with some of the most important advanced signal processing techniques, including multi-rate processing and time-frequency analysis techniques.

This course is designed to provide the above learning outcomes which arise from targeted graduate capabilities listed in ***Appendix A***. The targeted graduate capabilities broadly support the UNSW and Faculty of Engineering graduate capabilities (listed in ***Appendix B***). This course also addresses the Engineers Australia (National Accreditation Body) Stage I competency standard as outlined in ***Appendix C***.

Syllabus (as per handbook entry)

- FIR lattice filters; all-pole IIR lattice filters and their implementation.
- Fixed-point or finite word length implementations and effects.
- Random processes; auto-correlation; cross-correlation; and power spectrum estimation.
- Least squares filter design and relation to other filter design techniques;
- Adaptive filters; wiener filters; adaptive noise cancellation.
- Linear prediction and applications of linear prediction.
- Multi-rate signal processing systems; quadrature mirror filter banks; multilevel filter banks.
- Time frequency analysis; short-time Fourier transform; and wavelet transform.

Teaching Strategies

Delivery Mode

The teaching in this course aims at establishing a good fundamental understanding of the areas covered using:

- Formal face-to-face lectures, which provide you with a focus on the core analytical material in the course, together with qualitative, alternative explanations to aid your understanding;
- Tutorials, which allow for exercises in problem solving and allow time for you to resolve problems in understanding of lecture material, while also providing opportunities for you to stretch your understanding to a variety of application domains;
- Laboratory sessions, which support the formal lecture material and allow you to develop confidence in your ability to convert the formal material into solutions to important practical problems.

Learning in this course

You are expected to attend all lectures, tutorials, labs, and mid-semester tests. You must prepare well for your laboratory classes and your lab work will be assessed. You are expected to read the typeset course lecture notes carefully and thoughtfully. Reading additional texts may further enhance your learning experience, but is not essential. Group learning is also encouraged. UNSW *assumes* that self-directed study of this kind is undertaken in addition to attending face-to-face classes throughout the course.

Tutorial classes

You should attempt all of your problem sheet questions in advance of attending the tutorial classes. The importance of adequate preparation prior to each tutorial cannot be overemphasized, as the effectiveness and usefulness of the tutorial depends to a large extent on this preparation. Group learning is encouraged. Answers for these questions will be discussed during the tutorial class and the tutor will cover the more complex questions in the tutorial class.

Note: while official solutions to problem sets may be made available, reading solutions without first devoting substantial thought to the problems (including revision of lecture notes) is entirely counter-productive and can deprive you of the opportunity to truly come to grips with weaknesses in your understanding. A superior method of study is to discuss challenging questions with your peers, rather than reading solutions.

Laboratory program

You will find that the assessed laboratories require careful preparation, which is best done by reviewing lecture materials to the point where you understand them thoroughly. You will find that the work put into laboratories more than pays for itself, because preparing for the laboratories is one of the most effective study techniques for the course as a whole.

Laboratory Exemption

There is no laboratory exemption for this course. Regardless of whether equivalent labs have been completed in previous courses, all students enrolled in this course must take the labs. If, for medical reasons, (note that a valid medical certificate must be provided) you are unable to attend a lab, you will need to apply for a catch-up lab during another lab time, as agreed by the laboratory coordinator.

Assessment

The assessment scheme in this course reflects the learning objectives. Assessment in laboratories is intended to encourage you to get the most from these learning experiences. Mid-session tests encourage you to keep on top of the material and to allow both you and your lecturer to discover weaknesses in understanding early. Assessment in the final exam is very important to overall learning in the course; preparation for the final exam provides the best opportunity to appreciate the course as a whole and cement your understanding of its heavily interlinked concepts.

Laboratory Assessment

Laboratories are entirely about learning and understanding what you have learned. The laboratory assessment is designed to check your knowledge and understanding as you progress through the course.

Apart from the laboratory in Week 2, all laboratories in the course are assessed within the lab itself. Each of the five assessed labs contributes 5% to your overall mark, but is worth much more in the confidence that it can build and the understanding it can impart.

It is essential that you complete the laboratory preparation before coming to the lab. The laboratories in this course are not “demonstrations.” Instead they are design exercises, where you design a solution to a problem, implement it and explore the behaviour of your solution. This means that you need to create and test most, if not all of your solution before coming to the laboratory. In doing this, you will typically find the need to revise your lecture notes to deepen your understanding of the topic that is covered by the laboratory. This is intended and it is expected that you can demonstrate familiarity with all the relevant lecture material while being assessed.

The laboratory demonstrators are extremely knowledgeable and helpful and can help you to resolve weaknesses in your understanding, but you must raise any concerns that need their assistance near to the beginning of the scheduled laboratory period. Most of their time in the last two hours of the laboratory will be spent assessing your work. You can get all of your work assessed at once, or you can ask the laboratory demonstrators to assess your work in stages. If they discover problems with one part of your solution, they will generally let you know what the problem is and give you an opportunity to correct the errors and be re-assessed, but this might only be possible if you show them your work near to the beginning of the laboratory session.

You should follow all instructions given by the laboratory demonstrators to facilitate efficient assessment of your work. Where analytical work is involved, you should have that work available for the laboratory demonstrators to inspect, in a separate neatly presented laboratory book.

Mid-Semester Tests

The two mid-session tests will be conducted, in weeks 6 and 12, to probe your general understanding of the course material and provide you with feedback on your progress through the analytical components of the course. Questions may be drawn from any course material up to the end of the week preceding the relevant mid-session test. Marks will be assigned according to the correctness of the responses.

Mid-semester tests are closed book assessments. You will not be permitted to refer to your lecture notes or any other written materials during the test. Moreover, it is a serious offence to copy or use answers obtained from any of your classmates during these tests.

Final Exam

The exam in this course is a standard closed-book 3 hour written examination. University approved calculators are allowed. The examination tests analytical and critical thinking and general understanding of the course material in a controlled fashion. Questions may be drawn from any aspect of the course, unless specifically indicated otherwise by the lecturer. Marks will be assigned according to the correctness of the responses.

You will be permitted to bring one A4 sheet of paper, containing your own handwritten notes, on both sides of the sheet if required.

Course Resources

Textbooks

Prescribed:

- A complete set of typeset lecture notes for the course, written by Prof. Taubman, are available via the course web-site. These might be ammended from time to time over the running of the course, but are nonetheless very stable. They should be treated like a textbook and read carefully as essential prescribed material for the course.

Reference books you may find helpful:

- Proakis & Manolakis, *Digital Signal Processing: Principles, Algorithms and Applications*, Prentice Hall.
- Simon Haykin, *Modern Filters*, Macmillan Publishing Company.

On-line resources

Course Web-site:

For all course materials, project descriptions, problem sets and so forth, the official web-site for this course is at http://subjects.ee.unsw.edu.au/~elec4621.

Announcements:

Announcements concerning course information will be given in the lectures and/or via the course web-site. You might also be sent email with important announcements, which will be sent to your student email address.

Other Matters

Academic Honesty and Plagiarism

Plagiarism is the unacknowledged use of other people's work, including the copying of assignment works and laboratory results from other students. Plagiarism is considered a form of academic misconduct, and the University has very strict rules that include some severe penalties. For UNSW policies, penalties and information to help you avoid plagiarism, see http://www.lc.unsw.edu.au/plagiarism. To find out if you understand plagiarism correctly, try this short quiz: https://student.unsw.edu.au/plagiarism-quiz.

Student Responsibilities and Conduct

Students are expected to be familiar with and adhere to all UNSW policies (see https://my.unsw.edu.au/student/atoz/ABC.html), and particular attention is drawn to the following:

Workload

It is expected that you will spend at least **ten to twelve hours per week** studying a 6 UoC course, from Week 1 until the final assessment, including both face-to-face classes and *independent, self-directed study*. In periods where you need to need to complete assignments or prepare for examinations, the workload may be greater. Over-commitment has been a common source of failure for many students. You should take the required workload into account when planning how to balance study with employment and other activities.

Attendance

Regular and punctual attendance at all classes is expected. UNSW regulations state that if students attend less than 80% of scheduled classes they may be refused final assessment.

Also, based on past experience, the students who struggle most with the material in this subject are those who fail to attend all lectures.

General Conduct and Behaviour

Consideration and respect for the needs of your fellow students and teaching staff is an expectation. Conduct which unduly disrupts or interferes with a class is not acceptable and students may be asked to leave the class.

Work Health and Safety

UNSW policy requires each person to work safely and responsibly, in order to avoid personal injury and to protect the safety of others.

Special Consideration and Supplementary Examinations

You must attend all examinations scheduled for your course, including in-class tests. You must also submit all assessable laboratory projects for assessment in the designated laboratory session and week, allowing adequate time for laboratory demonstrators to mark your work. You should seek assistance early if you suffer illness or misadventure which affects your course progress. All applications for special consideration must be **lodged online through myUNSW within 3 working days of the assessment**, not to course or school staff. For more detail, consult the following URL:

https://my.unsw.edu.au/student/atoz/SpecialConsideration.html.

Continual Course Improvement

This course is under constant revision in order to improve the learning outcomes for all students. Please forward any feedback (positive or negative) on the course to the course convener or via the Course and Teaching Evaluation and Improvement Process. You can also provide feedback to ELSOC who can raise your concerns or positive feedback at student focus group meetings. As a result of previous feedback obtained for this course and in our efforts to provide a rich and meaningful learning experience, we have continued to evaluate and modify our delivery and assessment methods.

One change that was introduced this year in response to previous years' feedback has been to extend the lectures to 3 hours per week. While it might not be necessary for all 3 hours to be used in every week, this will provide sufficient opportunity for students to absorb challenging concepts. Students are strongly encouraged to ask questions during lectures, in response to which the lecturer will provide alternate perspectives on the material to clear up any misunderstandings.

Administrative Matters

On issues and procedures regarding such matters as special needs, equity and diversity, occupational health and safety, enrolment, rights, and general expectations of students, please refer to the School and UNSW policies:
http://www.engineering.unsw.edu.au/electrical-engineering/policies-and-procedures
https://my.unsw.edu.au/student/atoz/ABC.html

Appendix A: Targeted Graduate Capabilities

Electrical Engineering and Telecommunications programs are designed to address the following targeted capabilities which were developed by the school in conjunction with the requirements of professional and industry bodies:

- The ability to apply knowledge of basic science and fundamental technologies;
- The skills to communicate effectively, not only with engineers but also with the wider community;
- The capability to undertake challenging analysis and design problems and find optimal solutions;
- Expertise in decomposing a problem into its constituent parts, and in defining the scope of each part;
- A working knowledge of how to locate required information and use information resources to their maximum advantage;
- Proficiency in developing and implementing project plans, investigating alternative solutions, and critically evaluating differing strategies;
- An understanding of the social, cultural and global responsibilities of the professional engineer;
- The ability to work effectively as an individual or in a team;
- An understanding of professional and ethical responsibilities;
- The ability to engage in lifelong independent and reflective learning.

Appendix B: UNSW Graduate Capabilities

The course delivery methods and course content directly or indirectly addresses a number of core UNSW graduate capabilities, as follows:

- Developing scholars who have a deep understanding of their discipline, through lectures and solution of analytical problems in tutorials and assessed by assignments and written examinations.
- Developing rigorous analysis, critique, and reflection, and ability to apply knowledge and skills to solving problems. These will be achieved by the laboratory experiments and interactive checkpoint assessments and lab exams during the labs.
- Developing capable independent and collaborative enquiry, through a series of tutorials spanning the duration of the course.

- Developing independent, self-directed professionals who are enterprising, innovative, creative and responsive to change, through challenging design and project tasks.

Appendix C: Engineers Australia (EA) Professional Engineer Competency Standard

	Program Intended Learning Outcomes	
PE1: Knowledge and Skill Base	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals	✓
	PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing	✓
	PE1.3 In-depth understanding of specialist bodies of knowledge	✓
	PE1.4 Discernment of knowledge development and research directions	
	PE1.5 Knowledge of engineering design practice	✓
	PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice	
PE2: Engineering Application Ability	PE2.1 Application of established engineering methods to complex problem solving	✓
	PE2.2 Fluent application of engineering techniques, tools and resources	✓
	PE2.3 Application of systematic engineering synthesis and design processes	
	PE2.4 Application of systematic approaches to the conduct and management of engineering projects	
PE3: Professional and Personal Attributes	PE3.1 Ethical conduct and professional accountability	
	PE3.2 Effective oral and written communication (professional and lay domains)	✓
	PE3.3 Creative, innovative and pro-active demeanour	✓
	PE3.4 Professional use and management of information	
	PE3.5 Orderly management of self, and professional conduct	✓
	PE3.6 Effective team membership and team leadership	