ELEC3104: Digital Signal Processing

COURSE INTRODUCTION – Session 1, 2008

Course Staff

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Course details

Credits

The course is a 6 UoC course; expected workload is 10–12 hours per week throughout the 12 week session.

Contact hours

The course consists of 2 hours of lectures, a 1-hour tutorial, and a 2-hour laboratory session each week. These face-to-face hours are supplemented by a DVD with pre-recorded lectures that students are required to watch in their own time before class each week.

Lectures: Tuesday, 12–2pm, Room: Rex Vowels
Thursday, 17–18pm, Room: Rex Vowels

Consultations: You are encouraged to ask questions on the course material after the lecture class times in the first instance, rather than by email.

Course Information

Context and aims

Signal Processing is the process of measuring, manipulating or analysing information. Signals of interest include biomedical data, audio, still or moving images, radar, and even DNA. Filtering techniques can be crucial in revealing and interpreting information present in a signal. ELEC3104 Digital Signal Processing is an introductory signal processing course which takes students through the steps necessary to design and implement filters for a range of signals.

Aims

The course aims to equip the student to do the following:

- Deduce and understand the behaviour of a system in terms of both its time domain and frequency domain representations.

- Identify the correct type of filter required for a given problem and be able to demonstrate the design and implementation of such a digital filter.
- Explain the concept of aliasing and its effect on the design and use of practical systems.

Relation to other courses

The course is a third year subject in the school of Electrical Engineering and Telecommunications at the University of New South Wales. It is a core subject for students following a BE (Electrical) or (Telecommunications) program, and an elective for Computer or Software engineering students.

Pre-requisites

The pre-requisites for this course is ELEC2134, Circuits and Signals. It is essential that students are familiar with basic circuit theory and signal analysis.

Assumed knowledge

It is further assumed that the students are familiar with the MATLAB environment, and have good computer literacy.

Following courses

The course is a pre-requisite for all professional electives in the Signal Processing group, including ELEC4621 Advanced Digital Signal Processing, ELEC4622 Multimedia Signal Processing, and ELEC4623 Biomedical Instrumentation, Measurement and Design.

Old courses

The course replaces the previous course ELEC3004.

Learning outcomes

At the end of the course you should:

- Be familiar with transform methods of analysing analogue and digital linear time-invariant systems
- Be familiar with both time and frequency domain representations of signals and systems
- Be familiar with the practical aspects of sampling and reconstruction, analog and digital filter design, windowing and the discrete time Fourier transform
- Have gained practical experience with the implementation of digital filters

The course delivery methods and course content address a number of core UNSW *graduate attributes*; these include:

- Analytical skills, critical thinking and creative problem solving will be developed by the laboratory experiments and interactive checkpoint assessments during the labs.
- Self-assessment of independent and reflective learning is made available through a series of tutorials spanning the duration of the course and online laboratory quizzes to assess knowledge, together with the DVD-based learning material. The laboratory program fosters independent learning.

- Demonstration of the understanding of principles, and the effective use and communication of relevant information will be tested in depth in the two class examinations and the final presentation.

Syllabus

Processing and analysis of continuous (analogue) and discrete-time (digital) signals. Sampling continuous signals: the sampling theorem, reconstruction, aliasing and the z-transform. Analogue filters: Butterworth filters. Filter impulse and frequency responses, stability and digital oscillators. The discrete Fourier transform (DFT) and the fast Fourier transform (FFT). Fundamentals of the design and realisation of finite impulse response (FIR) and infinite impulse response (IIR) digital filters. Linear and non-linear phase. Decimation, interpolation, multi-rate digital signal processing.

Teaching strategies

Delivery Mode

This entire course will be structured around Project-Based Learning (PBL). PBL replaces older-style teaching methods with self-directed learning, centring not around a series of lectures on theoretical information, but rather the solution to a particular problem. In arriving at the solution to the problem you will encounter in the lab sessions, you will research relevant technologies or procedures, design a strategy and implement a system. In this way many different solutions are possible to the same initial problem. Learning is thus much more student-centred than in traditional lecture-based courses, as you will learn the material naturally and progressively as part of the work to arrive at their solution. With the material structured around the laboratory work, the course is intended to imitate the real-life experience of engineering design, moving from problem analysis to design to the final communication of that solution. These skills will be invaluable both in the remainder of your university career and in the professional workplace.

In addition, this entire course will be delivered in a *new mode of teaching*, using DVD-based lecture presentations. The live lectures will act as a supplement to explain and elaborate on the material on the DVD. You will need to watch these DVD-based lectures in your own time before the weekly lecture/discussion class. Advantages of the DVDs are:

- You will be able to watch them at your own pace
- You can revisit the lecture content as many times as you like
- Things that you might miss in a normal live lecture (e.g. difficult mathematical concepts) are available on the DVD and/or via the discussion classes

This mode of delivery was used in 2006-2007 for this course, and it was popular with both undergraduate and postgraduate students in other courses who said that it helped them gain a deeper understanding of the course material. The DVDs will use new VCPlayer software developed here at the School of Electrical Engineering and Telecommunications.

Note that the laboratory material and the lecture material may **not** be entirely synchronised. The pre-recorded lectures on DVD provide you with an opportunity to cover material not yet covered in class. You should look through the laboratory notes to decide what material you need to look over.

Any student comments specifically about any issues with this mode of teaching should be directed to the course convener.

Laboratory program

The laboratory program is the centre of this course. Through the project-based learning of the laboratory component, you will progressively encounter the elements of the syllabus. The aim of the laboratory component is to ground the analytical subject material in a real-world problem, meaning that the skills and knowledge you learn throughout the course will be applied in real engineering design work. Throughout the semester you will design a spectrum analyser, and implement your solution in MATLAB (please refer to the laboratory handout for more information). You will be focusing in particular on:

- Sampling and reconstruction
- Impulse and frequency response of systems
- Description of filter types using poles and zeroes
- Digital filter design

Assessment

The assessment scheme in this course reflects the intention to assess your learning progress through the session. Ongoing assessment through the session occurs through the lab checkpoints and the class tests, and culminates with a spoken presentation on your lab work in week 12.

Session Test I (week 6)	= 20%
Session Test II (week 11)	= 20%
Ongoing Lab Assessment	= 40%
Lab Presentation (week 12)	= 10%
Lab Quizzes (WebCT)	= 10%

No Final Exam

Week 0 (Compulsory) – Pre-requisite Signals and Systems Quiz

Before you can start the laboratory program you will have to attend the laboratory in week 0. You will not be able to start the first week of lab work unless you attend this week 0 lab session. During this lab time you will have an introduction to Matlab, and a short online quiz will be conducted covering the material of 2nd-year Circuits and Signals (ELEC2134). Students are advised to look over 2nd-year lecture notes before attempting this quiz. Aptitude in both Matlab and these fundamentals of signal theory are crucial for your ability to pass this course.

Session Tests (20% each)

There will be two session examinations, testing your understanding of the principles and your analytical skills.

Session Examination 1

- Thursday, 17th April (Week 6), 6:15-7:45pm, Rex Vowels Theatre.
- Covers material from chapters 1, 2, 3, 4, 5

Session Examination 2

- Thursday, 29th May (Week 11), 6:15-7:45pm, Rex Vowels Theatre.
- Covers material from chapters 6, 7, 8, 9

Laboratory Assessment (40%)

Throughout the semester your progress in the laboratory will be assessed by your lab tutor at a series of checkpoints. At these checkpoints you will present your work to your tutor, explain the relevant concepts, and answer questions on your design. More information is available in the Laboratory notes.

Laboratory Presentation (10%)

In week 12, at the end of the laboratory program, you will individually present your overall project to a group of tutors in a 10-minute presentation. More information is available in the Laboratory notes.

Laboratory WebCT Quizzes (10%)

Throughout the semester you will be required to complete a series of small quizzes in the laboratory, accessed via WebCT. These will test your analytical skill in solving DSP problems such as signal analysis and filter design, covering the material you require for the current laboratory stage. You will do each quiz in the same week you present your work to your tutor for a checkpoint. A schedule is provided in the laboratory notes.

Laboratory Exemption

There is no laboratory exemption for this course as this is a PBL course. Regardless of whether equivalent labs have been completed in previous courses, all students enrolled in this course for Session 1, 2008 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 co-ordinator.

Pre-requisite to pass the course

A satisfactory performance (50% or greater) in the **ongoing laboratory assessment and lab presentation** is a necessary requirement to pass this course, irrespective of your marks in the other components. Furthermore, a pass mark (50% or greater) must be achieved in **session exam 2 (week 11)**.

Resources for Students

Textbooks

Prescribed textbook

- S. K. Mitra, Digital Signal Processing, McGraw-Hill, 2006

Reference books

- J. Proakis & D. Manolakis, Digital Signal Processing, Prentice-Hall, 1996.
- A. V. Oppenheim, R. W. Schafer, & P. Buck, Discrete-Time Signal Processing, Prentice-Hall, 1999.

On-line resources

WebCT

As a part of the teaching component, WebCT will be used for lab quizzes. WebCT online quizzes may be completed either in the laboratory or in your own time. There will be approximately one quiz for each section of the laboratory program. These quizzes will be assessed, contributing 10% of your final mark, and are intended to be a reflection of your understanding of the relevant course material. Class examination results will also be available via WebCT, soon after each examination.

Course web page: `http://subjects.ee.unsw.edu.au/elec3104`
Course WebCT `http://vista.elearning.unsw.edu.au`

Mailing list

Announcements concerning course information will be given in the lectures, via the course website and/or on WebCT.

Other matters

Academic Honesty and Plagiarism

Plagiarism is the unacknowledged use of other peoples work, including the copying of assignment works and laboratory results from other students. Plagiarism is considered a serious offence by the University and severe penalties may apply:
`http://www.lc.unsw.edu.au/plagiarism`

Continual Course Improvement

Students are advised that the course is under constant revision in order to improve the learning outcomes of its 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.

Administrative Matters

On issues and procedures regarding such matters as special needs, equity and diversity, occupational heath and safety, enrolment, rights, and general expectations of students, please refer to the School policies: `http://scoff.ee.unsw.edu.au/`

Important Points

Please note the following:

- During your lab sessions, you will be assigned to a lab tutor, who will be able to guide you in your project-based learning. The list of tutors will be available at the School Office.
- You will be able to purchase the lecture notes (hard copy) which contains course outline, problem sheets and sample quizzes and final exam papers, references, laboratory manual along with lecture notes. This costs $25 and can be purchased from the School Office.
- As there is no final exam, it is vital that you attend all tutorials, labs and the lectures.

Course Schedule

Week	Topic
1-2	Chapter 1: Signal and Systems
	Chapter 2: Discrete-Time Systems
	Chapter 3: An Introduction to the *z*-Transform
3-5	Chapter 4: Digital Signal Processing
	Chapter 5: Digital Filters
6	Chapter 6: Discrete-Time Fourier Transform
	Semester Exam 1 (chapters 1, 2, 3, 4, 5)
7	Chapter 7: Analogue Filter Design
8	Chapter 8: Digital Filter Design
9	Chapter 8: Digital Filter Design
10	Chapter 9: Multirate Digital Signal Processing
11	Chapter 9: Multirate Digital Signal Processing
	Semester Exam 2 (chapters 6, 7, 8, 9)
12	**Lab presentation**

Laboratory Schedule and Class Tests

Week	Suggested Lab work	Checkpoint due	Required Reading
0	Introduction to Matlab	Signals & Systems online quiz	ELEC2134 Lecture notes or an equivalent
1	Section 1 – Sampling		Chapter 1, 2
2	Section 1 – Sampling	Checkpoint 1	Chapter 1, 2
3	Section 2 – Filter Design	WebCT Lab Quiz 1	Chapter 3, 4, 5
4	Section 2 – Filter Design	Checkpoint 2.1	Chapter 3, 4, 5
5	Section 2 – Filter Design	Checkpoint 2.2	Chapter 3, 4, 5, 7
6	**No laboratory (Session Test 1)**		
7	Section 3 – Frequency Analysis	WebCT Lab Quiz 2	Chapter 3, 4
8	Section 4 – Rectification	Checkpoint 3	Chapter 1, 3, 5
9	Section 5 – Modulation	WebCT Lab Quiz 3	Chapter 1, 3, 5
10	Section 6 – Multi-rate Processing	Checkpoint 4/5	Chapter 8, 9
11	Section 6 – Multi-rate Processing	Checkpoint 6 & WebCT Lab Quiz 4	Chapter 8, 9
12	**Lab Presentation**		**All laboratory exercises**

CATEI Results (S1 and S2, 2007)

The university strongly encourages students to give their feedback at the conclusion of the course. Results from an online survey of ELEC3104 Digital Signal Processing in 2007 (S1 and S2) are shown below. In 2008, we will be endeavouring to improve on the quality of the feedback given by you, assessment methods, tutorial support etc. Please note that the survey assumes that respondents have attended at least 80% of the class contact time.

Student Evaluation of a Course
ELEC3104 - Digital Signal Processing (S1, 2007)

Project Based Learning (PBL)

		A %	D %
Q1.	The aims of this course were clear to me	85	15
Q2.	I was given helpful feedback on how I was going in the course	77	23
Q3.	The course was challenging and interesting	87	13
Q4.	The course provided effective opportunities for active student participation in learning activities	82	18
Q5.	The course was effective for developing my thinking skills (e.g. critical analysis, problem solving).	84	16
Q6.	I was provided with clear information about the assessment requirements for this course.	76	24
Q7.	The assessment methods and tasks in this course were appropriate given the course aims	73	27
Q8.	The course advanced my ability for independent learning and critical analysis	84	16
Q9.	Good resources in laboratories and tutorials supported the learning process	59	41
Q10.	Overall, I was satisfied with the quality of this course	80	22

A - Agree; D- Disagree

Student Evaluation of a Course
ELEC3104 - Digital Signal Processing (S2, 2007)

		A %	D %
Q1.	The aims of this course were clear to me	96	4
Q2.	I was given helpful feedback on how I was going in the course	84	16
Q3.	The course was challenging and interesting	100	0
Q4.	The course provided effective opportunities for active student participation in learning activities	92	8
Q5.	The course was effective for developing my thinking skills (e.g. critical analysis, problem solving).	96	4
Q6.	I was provided with clear information about the assessment requirements for this course.	88	12
Q7.	The assessment methods and tasks in this course were appropriate given the course aims	100	0
Q8.	The course advanced my ability for independent learning and critical analysis	92	8
Q9.	Good resources in laboratories and tutorials supported the learning process	88	12
Q10.	Overall, I was satisfied with the quality of this course	92	8