ELEC3104: Digital Signal Processing

COURSE INTRODUCTION – Semester 1, 2009

Course Staff

Course convener:	Prof. E. Ambikairajah, room G6, ambi@ee.unsw.edu.au
Tutor:	Mohaddeseh Nosratighods m.nosratighods@unsw.edu.au
Laboratory Coordinator:	Tharmarajah Thiruvaran: thiruvaran@student.unsw.edu.au
WebCT Assistant:	Jiong An, jiongan@ee.unsw.edu.au

Course details

Credits

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

Contact hours

The course consists of 3 hours of lectures, a 1-hour tutorial, and a 2-hour laboratory session each week. These face-to-face hours are supplemented by a CD with pre-recorded lectures that students are required to watch in their own time before class each week.

Lectures: Tuesday 11am - 1pm, Room: ElecEngG24
Thursday 11am – 12 noon, Room: ElecEngG24

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 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 able to apply transform methods to the analysis of analogue and digital linear time-invariant systems
- Be able to convert between time and frequency domain representations of signals and systems
- Understand the practical aspects of sampling and reconstruction and be able to select a suitable sampling rate for a given signal processing problem
- Be capable of designing and analysing analog and digital filters for a given specification
- Be able to demonstrate an understanding of the use and applications of the discrete 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 CD-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 delivered in a *new mode of teaching*, using CD-based lecture presentations. The live lectures will act as a supplement to explain and elaborate on the material on the CD. You will need to watch these CD-based lectures in your own time before the weekly lecture/discussion class. Advantages of the CDs 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 CD and/or via the discussion classes

This mode of delivery was used from 2006 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 CDs 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 CD 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.

Teaching Methods

Lectures = 3 hrs/week *(mandatory)* Tutorials = 1 hr/week *(mandatory)*

Labs = 2 hrs/week *(mandatory)*

The rationale behind the teaching methods for this course:

- The course is structured such that the lecture classes provide an in depth understanding of the course material. The CD based lectures provide details of course material so that you can understand each concept presented and re-visit any difficult sections in detail.
- The tutorials help to develop the required level of analytical skills that will be used in this course.
- Your 2 class exams, test your problem solving skills and give you the opportunity to effectively communicate and demonstrate your understanding of the principles in the course.
- The lab quizzes will test your weekly preparation methods for the lab work and ensure that you are sufficiently prepared to take the lab.
- The final presentation in the lab tests your ability to communicate technical ideas to your peers in a confident manner and demonstrate your independent learning.

The learning in this course is intensive for all 12 weeks of the semester and there is no final exam.

Learning in this course

You are expected to attend all lectures, tutorials, labs, lab quizzes and class exams in order to maximise learning. You should prepare your tutorial questions in advance of attending the tutorial classes. You must prepare well for your laboratory classes and will be tested on this preparation by a quiz at the beginning of each lab. In addition to the lecture notes/CD, you should read relevant sections of the recommended text. Reading additional text would further enhance your learning experience. Group learning is also encouraged.

Laboratory program

The laboratory program is the centre of this course. Through 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 focus on:

- Sampling and reconstruction
- Impulse and frequency response of systems
- Description of filter types using poles and zeroes
- Digital filter design
- Frequency domain analysis
- Multi-rate processing

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 for Semester 1, 2009 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 **each** of the following, is a necessary requirement to pass this course:

- **ongoing laboratory assessment**
- **lab presentation**
- **semester exam 2 (week 11)**

Assessment

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

Semester Exam I (week 6)	= 20%
Semester Exam II (week 11)	= 25%
Ongoing Lab Assessment	= 35%
Lab Presentation (week 12)	= 10%
Ongoing lab Quizzes (WebCT)	= 10%

No Final Exam

Semester Examinations (45% total)

There will be two examinations, testing your understanding of the principles and your analytical skills through a number of set problems.

Semester Examination 1

- Thursday, 23th April (Week 6), 6:15-7:45pm, Rex Vowels Theatre.
- Covers material from chapters 1, 2, 3, 4, 5,6

Semester Examination 2

- Thursday, 28th May (Week 11), 6:15-7:45pm, Rex Vowels Theatre.
- Covers material from chapters 7, 8, 9

If for medical reasons, (note that a valid medical certificate must be provided) you are unable to attend a class exam, you will be given an **oral examination** of approximately 1 hour.

Laboratory Assessment (35%)

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 labs. Marks will be assigned according to the broad criteria explained in the Laboratory notes.

Laboratory Presentation (10%)

In week 12, at the end of the laboratory program, you will individually present your overall laboratory skills that you have learnt to a group of tutors in a 10-minute presentation. Marks will be assigned for oral technical communication skills, theoretical understanding, and correctness of responses to questions.

Laboratory WebCT Quizzes (10%)

Throughout the semester you will be required to complete a series of small multiple-choice 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, i.e. these are preparation quizzes. In each case, your mark will be determined by how well you have prepared for the laboratory and understood the underlying theory for the laboratory. A schedule is provided in the laboratory notes.

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`
Video Lectures	`http://eemedia.ee.unsw.edu.au:80/ELEC3104`

Mailing list

Announcements concerning course information will be given in the lectures, via the course website `http://subjects.ee.unsw.edu.au/elec3104` 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 demonstrator, who will be able to guide you in your laboratory-based learning.
- You will be able to purchase the lecture notes (hard copy + CD based lectures) which contains course outline, MATLAB exercises, tutorial problem sheets and solutions, sample quizzes, final exam papers, references and laboratory manual along with lecture notes. This costs $25 and can be purchased from the School Office.
- A soft copy of the lecture notes is available on the course website:
  http://subjects.ee.unsw.edu.au/elec3104
- As there is no final exam, it is vital that you attend all tutorials, labs and the lectures.
- Guidelines on learning that inform teaching at UNSW are available at www.guidelinesonlearning.unsw.edu.au

Course Schedule

Week	Topic
1-2	Chapter 1: Signal and Systems
	Chapter 2: Discrete-Time Systems
	Chapter 3: An Introduction to the *z*-Transform
	Chapter 4: Fourier Representation of Signals
3-5	Chapter 5: Digital Signal Processing
6	Chapter 6: Discrete-Time Fourier Transform
	Semester Exam 1 (chapters 1, 2, 3, 4, 5, 6)
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 7, 8, 9)
12	**Lab presentation**

Laboratory Schedule

Week	Suggested Lab work	Checkpoint due	Required Reading
1	Lab1 - Introduction to TIMS and Matlab		Matlab Exercises Chapter 1, 2, 4
2			
3	Lab 2 - Sampling and Reconstruction		Chapter 1, 2, 3, 4 5
4		WebCT Lab Quiz 1 Checkpoint 1(6%)	Chapter 1, 2, 3, 4, 5
5	Lab 3 Impulse and Frequency Response of Systems	Checkpoint 2 (6%)	Chapter 2, 3, 4, 5, 6
6	Lab 4 Poles and Zeros	WebCT Lab Quiz 2 Checkpoint 3 (6%)	Chapter 3, 4, 5, 6
7	Lab 5 Digital Filters		Chapter 5, 7, 8
8		Checkpoint 4 (6%)	Chapter 5, 7, 8
9	Lab 6 Interpolation and Decimation	WebCT Lab Quiz 3	Chapter 5, 7, 8, 9
10	Lab 7: Filtering with DSP chip	Checkpoint 5 (6%)	Chapter 5, 8, 9
11		WebCT Lab Quiz 4 Checkpoint 6 (5%)	Chapter 5, 8, 9
12	**Lab presentation**	**(10%)**	**All laboratory exercises**

CATEI Results (S2, 2007 and S1 2008)

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 and 2008 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 (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

A - Agree; D- Disagree

Student Evaluation of a Course
Problem Based Learning (PBL)
ELEC3104 - Digital Signal Processing (S1, 2008)

		A %	D %
Q1.	The aims of this course were clear to me	98	2
Q2.	I was given helpful feedback on how I was going in the course	98	2
Q3.	The course was challenging and interesting	100	0
Q4.	The course provided effective opportunities for active student participation in learning activities	98	2
Q5.	The course was effective for developing my thinking skills (e.g. critical analysis, problem solving).	98	2
Q6.	I was provided with clear information about the assessment requirements for this course.	92	8
Q7.	The assessment methods and tasks in this course were appropriate given the course aims	94	4
Q8.	The course advanced my ability for independent learning and critical analysis	98	2
Q9.	Good resources in laboratories and tutorials supported the learning process	95	5
Q10.	Overall, I was satisfied with the quality of this course	100	0