School of Electrical Engineering and Telecommunications

Term 2, 2020
Course Outline

ELEC9721
Digital Signal Processing: Theory and Applications

COURSE STAFF

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Consultations: For T2, 2020, this course will run entirely online. You are encouraged to ask questions on the course material, during the allocated class times in the first instance, then in the online Moodle forum (so all students can benefit from the answer), and then via email. You are welcome to email staff, who can answer your questions on this course. ALL email enquiries should be made from your student email address with ELEC9721 in the subject line, otherwise they will not be answered.

Keeping Informed: Announcements will be made first using the forum in Moodle (https://moodle.telt.unsw.edu.au/login/index.php) and also in the live "synchronous" class times, or via email (to your student email address). 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 has 3 hours timetabled per week for live, on-line discussion. Lectures are recorded and available in Moodle. "Laboratories" are to be done in the student's own time and delivered as per the timetable below. The live sessions are to answer questions about lectures and assessable work – problems, labs, assignments, exams.

Lectures/ Laboratories	Day	Time	Location
	Monday	2pm - 5pm	online

Context and Aims

The course is an elective in EET programs: 8338 MEngSc Space Systems Engineering/ Electrical Engineering/ Telecommunications/ Systems and Control, and 8621 MEng Electrical Engineering.

ELEC9721 Digital Signal Processing and Applications, is a 6 UoC post-graduate course that aims to give students the fundamentals of digital signal processing as well as exploring some important and illustrative applications. The course starts by defining and understanding signals and why they are processed. It then investigates signal processing tools and the mathematical concepts they are based on. Finally, some applications demonstrate the concepts learned. Topics to be covered: digital signals and systems; digital filter design; statistical and adaptive signal processing; multi-rate systems and filter banks; time-frequency analysis; DSP applications.

Indicative Lecture Schedule

Wk No.	Lecture Material to be familiarised this week (recordings)	Laboratories Monday 2.00pm-5.00pm	Assignment material due 5pm Friday
1	Introduction to DSP		Problems 1
2	Z Transform	Lab 1A	
3	Digital Fourier Transform	Lab 1B	Problems 2, 3
4	Introduction to Digital Filters	Lab 2A	(Assignment available)
5	FIR and IIR Filters	Lab 2B	Problems 4, 5
6	Finite Wordlength Effects	Lab 3A	
7	Random Processes	Mid-Term Exam	Problems 6, 7
8	Adaptive DSP	Lab 3B	
9	Multirate DSP	Lab 4	Assignment due
10	Time-Frequency Analysis	Lab 5	Problems 8, 9, 10

Assessment

Assessment for the course includes:

- Laboratory 10%
- Assignments 35%
- Mid-term exam 15%
- Final examination 40%

Note: this course has assessments due every week: labs, problems, or both.

Laboratory (10%): Laboratories are Matlab programs to do specific signal processing tasks. They will run synchronously, i.e. they are done in real time, with lab demonstrators, using on-line tools, according to the timetable above. No lab reports are required in this course.

Assignments (35%): There are two types of assignments in the course: a major assignment to work on over several weeks, and short sets of problems arising from the lectures. The major assignment will be a Matlab program that solves a particular signal processing problem. Multiple different problems will be randomly assigned, one per student. There will be several weeks to work on the assignment. The submitted assignment will consist of a working Matlab .m file and a technical report. Problems (marked as questions and exercises in the lectures) must be answered by hand, photographed and uploaded using Moodle Assignment. This process is important, as it gives the student practice and familiarity with this process, which will be used in a timed fashion for the mid-term and final examinations. They are due according to the timetable abovet.

Mid-term examination (15%): The mid-term examination tests your general understanding of the course material, and questions may be drawn from any course material up to the end of week 5.

Final examination (40%): The exam in this course will be run using timed questions in Moodle assignment. The examination tests analytical and critical thinking and a thorough understanding of the course material in a controlled fashion. Please note that *you must pass the final exam in order to pass the course*.

COURSE DETAILS

Credits

This is a 6 UoC course and the expected workload is 15 hours per week throughout the 10-week term.

Relationship to Other Courses

This is a postgraduate course in the School of Electrical Engineering and Telecommunications, available to selected undergraduates. It is an elective in several MSc programs.

Pre-requisites and Assumed Knowledge

There are no formal pre-requisites for this course. Entry into the relevant MSc program is considered the qualification. It is essential that you are familiar with basic electronics and analogue signal processing before this course is attempted.

Following Courses

The course is not a pre-requisite.

Learning outcomes

After successful completion of this course, you should be able to:

1. Understand and explain fundamentals of Digital Signal Processing as well as knowledge of some of its important applications.
2. Understand and explain signals and transforms, filters, random variables and elementary statistical signal processing, and time frequency analysis among other topics
3. Implement key digital signal processing methods and algorithms

Upon successfully completing the course, students should have an understanding of Digital Signal Processing, as well as knowledge of some of its applications. Students will also understand signals and transforms, filters, random variables and statistical signal processing, and time-frequency analysis among other topics.

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

Sampling, transforms (Z, DTFT, DFT), FIR and IIR digital filter design and realisation, finite word length effects, random processes, adaptive filters, linear prediction, multi-rate signal processing, time-frequency analysis. Applications may include: tone detection, noise reduction, pitch estimation, etc.

TEACHING STRATEGIES

Delivery Mode

The course consists of the following elements: lectures, laboratory work, and tutorial questions. The lectures are the primary mode of teaching. Laboratory work is sometimes combined with analytical work as a form of assignment. The laboratories will be assessed regularly. Pre-preparation for laboratory work is essential, particularly for any analytical work corresponding to the laboratory. Tutorials also will be given regularly, which aim to provide in-depth quantitative and qualitative understanding of DSP concepts.
Laboratory classes can start from the first day.

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

- Formal 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;
- Laboratory sessions, which support the formal lecture material and also provide you with practical construction, measurement and debugging skills;

Learning in this course

You are expected to view all lectures and tutorials in order to maximise learning. In addition to the lecture notes/video, you should read relevant sections of the recommended texts and related technical materials. 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.

The core material for the course is the set of lecture notes. All that is required for the course is contained within them. The lectures have been derived from several sources. As with almost any software-based learning experience, there is no substitute for writing and running code. The more familiar the student is with the Matlab exercises, the more likely that person is to understand and be able to use the theoretical ideas presented in lectures.

"Tutorials"

You should attempt all of your problem questions. The importance of these problems cannot be overemphasized, as the effectiveness and usefulness of the lecture material depends to a large extent on this work. Group learning is encouraged.

Laboratory program

The laboratory schedule is deliberately designed to provide practical exposure to the concepts conveyed in lectures soon after they are covered in class. You are required to attend laboratory. Laboratory attendance WILL be kept, and you MUST attend at least 80% of labs.

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 intention to assess your learning progress through the term. Ongoing assessment occurs through the labs, problem assignments and the mid-term exam.

Laboratory Assessment

Laboratories are primarily about learning, and the laboratory assessment is designed mainly to check your knowledge as you progress through each stage of the laboratory tasks.

It is essential that you complete the laboratory preparation before attending the lab. Assessment marks will be awarded according to your preparation (completing set preparation exercises and correctness of these or readiness for the lab in terms of pre-reading), how much of the lab you were able to complete, your understanding of the experiments conducted during the lab, the quality of the code you write during your lab work, and your understanding of the topic covered by the lab.

Mid-Term Exam

The mid-term examination tests your general understanding of the course material, and is designed to give you feedback on your progress through the analytical components of the course. Questions may be drawn from any material already covered in the course schedule. It may contain questions requiring some (not extensive) knowledge of laboratory material, and will definitely contain numerical and analytical questions. Marks will be assigned according to the correctness of the responses.

Assignment

The assignment allows self-directed study leading to the solution of partly structured problems. Marks will be assigned according to how completely and correctly the problems have been addressed, the quality of the code written for the assignment (must be attached to the report), and the understanding of the course material demonstrated by the report.

The assignment report will be due Friday Week 9. *Late reports will attract a penalty of 10% per day* (including weekends).

Final Exam

The exam in this course is a 2 hour written examination, comprising five compulsory questions. 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 (including laboratory), unless specifically indicated otherwise by the lecturer. Marks will be assigned according to the correctness of the responses. *Please note that you must pass the final exam in order to pass the course.*

Relationship of Assessment Methods to Learning Outcomes

	Learning outcomes		
Assessment	**1**	**2**	**3**
Laboratory	✓	✓	✓
Problems	✓	✓	-
Mid-term exam	✓	✓	
Assignment	✓	✓	✓
Final exam	✓	✓	✓

COURSE RESOURCES

Textbooks

There are many signal processing books appropriate for this course. Some that were used in preparing the course are:

V K Ingle and J G Proakis, “Digital Signal Processing Using Matlab”, 4th ed., Cengage, 2017

M H Hayes, “Digital Signal Processing”, 2nd ed., Schaum’s Outlines, McGraw Hill, 2012

S D Stearns and D R Hush, “Digital Signal Procesing with examples in Matlab”, 2nd ed., CRC, 2014

J M Giron-Sierra, “Digital Signal Processing with Matlab Examples, vol 1”, Springer, 2017

S Ramamurthy, “Digital Filters and Signal Processing”, Medtec, 2014

On-line resources

Moodle

As a part of the teaching component, Moodle will be used to disseminate teaching materials, host forums and occasionally quizzes. Assessment marks will also be made available via Moodle: https://moodle.telt.unsw.edu.au/login/index.php.

Mailing list

Announcements concerning course information will be given in the lectures and/or on Moodle and/or via email (which will be sent to your student email address).

OTHER MATTERS

Dates to note

Important Dates available at: https://student.unsw.edu.au/dates

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 https://student.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://student.unsw.edu.au/policy), and particular attention is drawn to the following:

Workload

It is expected that you will spend at least **15 hours per week** studying a 6 UoC course, from Week 1 until the final assessment, including both formal classes and *independent, self-directed study*. In periods where you 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.

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 submit all assignments and attend all examinations scheduled for your course. You can apply for special consideration when illness or other circumstances beyond your control interfere with an assessment performance. If you need to submit an application for special consideration for an exam or assessment, you must submit the application **prior to the start** of the exam or before the assessment is submitted, except where illness or misadventure prevent you from doing so. Be aware of the "fit to sit/submit" rule which means that if you sit an exam or submit an assignment, you are declaring yourself well enough to do so and cannot later apply for Special Consideration. For more information and how to apply, see https://student.unsw.edu.au/special-consideration.

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 online student survey myExperience. You can also provide feedback to ELSOC who will raise your concerns 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.

For 2020:

Lectures have been recorded, in two parts: theoretical content, and worked examples. This allows more time in total for the lectures, as requested by several students, and fully worked examples, which was also requested. These changes account for more than 80% of 2019 comments.

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:
https://student.unsw.edu.au/guide
https://www.engineering.unsw.edu.au/electrical-engineering/resources

APPENDICES

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 digital and information literacy and lifelong learning skills through assignment work.
- Developing ethical practitioners who are collaborative and effective team workers, through group activities, seminars and tutorials.
- Developing independent, self-directed professionals who are enterprising, innovative, creative and responsive to change, through challenging design and project tasks.

- Developing citizens who can apply their discipline in other contexts, are culturally aware and environmentally responsible, through interdisciplinary tasks, seminars and group activities.

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	