School of Electrical Engineering and Telecommunications

Term 3, 2020
Course Outline

**ELEC3104**
Digital Signal Processing
(Online)

## COURSE STAFF

Course Convener:          Dr. Vidhyasaharan Sethu, Room EE442, v.sethu@unsw.edu.au
Course Co-Convener:       Dr. Kaavya Sriskandaraja, Room EE414, k.sriskandaraja@unsw.edu.au

Tutorial-Lab Coordinator:     TBC

**Consultations:** You are encouraged to ask questions on the course material, after the lecture class times in the first instance, rather than via email. In addition, a weekly open consultation time of 1 hour will be provided (details announced on Moodle). Any email enquiry regarding the course should be made from your student email address with ELEC3104 in the subject line; otherwise they will not be answered. All project related emails should be directed to Dr Kaavya Sriskandaraja in the first instance.

**Keeping Informed:** Announcements may be made during classes, via email (to your student email address) and/or via online learning and teaching platforms – in this course, we will use Moodle https://moodle.telt.unsw.edu.au/login/index.php. 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 (Fully Online)

The course consists of 4-5 hours of lectures (via Zoom), and a 2-hour of online tutorial-lab each week.

|  | Day | Time | Location |
|---|---|---|---|
| **Lectures** | Tuesday | 1600 – 1800/1900 | Zoom |
|  | Friday | 1500 – 1700 | Zoom |
|  |  |  |  |
| **Tutorial-Labs** | Wed-Thur | Enrolled Times | Microsoft Teams |

### Context

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 students with:
- An understanding of the behaviour of a system, in terms of both its time domain and frequency domain representations.
- The skills to identify the correct type of filter required for a given problem and be able to demonstrate the design and implementation of a digital filter.
- The ability to explain the concept of aliasing and its effect on the design of practical systems.
- An understanding of multi-rate processing and multi-rate systems.

**Indicative Lecture Schedule**

| Period | Summary of Lecture Program | Summary of Laboratory Program |
|---|---|---|
| Week 1 | Introduction + Understanding Signals | |
| Week 2 | Understanding Signals + Analysis of Discrete Systems | Tutorial-Lab 1 |
| Week 3 | Analysis of Discrete Systems | Tutorial-Lab 1 + Quiz |
| Week 4 | Discrete Fourier Transform | Tutorial-Lab 2 |
| Week 5 | Discrete Fourier Transform | Tutorial-Lab 2 + Quiz |
| Week 6 | *Flexibility Week (No lectures)* | |
| Week 7 | Filter Design | Project Assessment 1 |
| Week 8 | Filter Design + Multi-rate Processing | Tutorial-Lab 3 |
| Week 9 | Multi-rate Processing | Tutorial-Lab 3 + Quiz |
| Week 10 | Quantisation | Project Assessment 2 |

**Note:** MATLAB Tutorial Videos: **http://eemedia.ee.unsw.edu.au/MatlabTutorial/index.htm**

**Assessment**

| | |
|---|---|
| Online Quiz (3 Quizzes) | 20% |
| Project | 30% |
| Final Exam (2 hours) | 50% |

**Note:** You must pass both the Project and the Final Exam to pass the course

**Important Health Related Notice**

Your health and the health of those in your class is critically important. You must stay at home if you are sick or have been advised to self-isolate by NSW health or government authorities. Current alerts and a list of hotspots can be found here. **You will not be penalised for missing a face-to-face activity due to illness or a requirement to self-isolate**. We will work with you to ensure continuity of learning during your isolation and have plans in place for you to catch up on any content or learning activities you may miss. Where this might not be possible, an application for fee remission may be discussed.

If you are required to self-isolate and/or need emotional or financial support, please contact the Nucleus: Student Hub. If you are unable to complete an assessment, or attend a class with an attendance or participation requirement, please let your teacher know and apply for special consideration through the Special Consideration portal. To advise the University of a positive COVID-19 test result or if you suspect you have COVID-19 and are being tested, please fill in this form.

UNSW requires all staff and students to follow NSW Health advice. Any failure to act in accordance with that advice may amount to a breach of the Student Code of Conduct. Please refer to the Safe Return to Campus guide for students for more information on safe practices.

## 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 3rd year course in the School of Electrical Engineering and Telecommunications at the University of New South Wales. It is a core course for students following a BE (Electrical) or (Telecommunications) program and other combined degree programs, and an elective for Computer Engineering students.

### Pre-requisites and Assumed Knowledge

The pre-requisite for this course is ELEC2134, Circuits and Signals. It is essential that students are familiar with basic circuit theory, signal analysis and transform methods. It is further assumed that 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 and ELEC4622 Multimedia Signal Processing

### Learning outcomes

At the end of the course students should:
1. Be able to apply transform methods to the analysis of analogue and digital linear time-invariant systems
2. Develop the appropriate competency in converting between time and frequency domain representations of signals and systems
3. Understand the practical aspects of sampling and reconstruction and be able to select a suitable sampling rate for a given signal processing problem
4. Design and analyse analogue and digital filters for a given specification
5. Demonstrate an understanding of the use and applications of the Discrete Fourier transform
6. Have gained practical experience with the implementation of digital filters
7. Be able to implement a simple multi-rate system

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

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). Fundamentals of the design and realisation of finite impulse response (FIR) and infinite impulse response (IIR) digital filters. Linear and non-linear phase filters. Decimation, interpolation, multi-rate digital signal processing.

## TEACHING STRATEGIES

### Delivery Mode

This entire course will be delivered via online live lectures. Lecture notes of mathematical concepts and relationships will also be provided to complement the lectures. Please note that the notes and the lectures are designed to be complementary, you should not treat the notes as a replacement for lectures. In addition to lectures, the course also includes Tutorial-laboratory sessions, which provide you with opportunities to apply the ideas covered in the course to analytical and computational problems.

### Learning in this course

1. You are expected to attend <u>all</u> lectures, tutorial-labs, and complete the project in order to maximise learning.
2. You must prepare well for your tutorial-lab classes.

3. Reading additional texts will further enhance your learning experience.
4. Group learning is also encouraged.
5. You are encouraged to discuss your project design with your peers, but you should implement the project on your own.
6. UNSW *assumes* that self-directed study of this kind is undertaken in addition to attending face-to-face classes throughout the course.

**Tutorial-Laboratory classes**

The integrated tutorial-laboratory sessions are designed to help you develop your analytical skills and see how they are applicable in a practical context. You may divide your time between the analytical and the laboratory components as per your convenience, but you should complete both within the allocated time. The analytical problems you will be given in these sessions will tend to be more involved than the sample problems in the reference books and will also tend to involve more than one topic. **It is expected that you are able to solve the sample problems in each chapter and the recommended reference books prior to undertaking the tutorial-lab questions.**
A total of 3 tutorial-laboratory question sheets will have to be completed in this course and are designed to provide practical, hands-on exposure to the concepts conveyed in lectures soon after they are covered in class. While you are free to divide your laboratory time between these 3 sheets and project as you choose to, **you must complete tutorial-lab sheet 1 by week 3, tutorial-lab sheet 2 by week 5 and tutorial-lab sheet 3 by week 9.** You MUST engage with all tutorial-lab sessions.

The project is designed to provide a hands-on exposure to the applications of the concepts learnt in the course in implementing a DSP system. You are free to split your laboratory time between the tutorial-lab sheets and the project, but you are strongly encouraged to discuss your project implementation with your lab demonstrators to complement your self-directed learning. **The project will be assessed based on an INDIVIDUAL presentation in week 7 & 10. Attendance for this is compulsory.**

You should attempt all 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.

**Tutorial-Laboratory Exemption**

<u>There is no laboratory exemption for this course</u>. 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 online quizzes and the project presentation in the final week.

| | |
|---|---|
| Online Quizzes | 20% |
| Individual Project Presentation (Weeks 7 & 10) | 30% |
| Final Exam (2 hours) | 50% |

**Online Quizzes (20%)**
The quizzes are online tests that will be given in weeks 3, 5, and 9. These will focus on analytical concepts covered in the tutorial-lab sheets.

**Project (30%)**
The project will comprise of two stages. The first stage will be evaluated in week 7 and the second stage in week 10. At both stages, your project will be assessed by your lab demonstrator(s) in terms of both your implementations (based on a working demonstration) and your understanding (based on your verbal answers to questions from the demonstrators). **You must pass the project to pass the course.**

**Final Exam (50%)**

The exam in this course is a two-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. **You must pass this final exam to pass the course.**

- The final exam will be 2 hours long
- The final exam will cover all chapters covered in the term

**Relationship of Assessment Methods to Learning Outcomes**

| Assessment | Learning outcomes | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Online Quizzes (20%) | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| Project (30%) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | - |
| Final examination (50%) | ✓ | ✓ | ✓ | ✓ | ✓ | - | ✓ |

# COURSE RESOURCES

**Reference books**

- A. V. Oppenheim, R. W. Schafer, & P. Buck, Discrete-Time Signal Processing, Prentice-Hall, 2010.
- S. K. Mitra, Digital Signal Processing, McGraw-Hill, 2011.
- R. G. Lyons, Understanding Digital Signal Processing, 3rd ed, Prentice-Hall, 2011
- J. Proakis & D. Manolakis, Digital Signal Processing, Prentice-Hall, 2007.
- A. Antoniou, Digital Signal Processing – Signals, Systems and Filters, McGraw-Hill, 2016

**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.

Given the current circumstances and based on previous experience for this course (2019-2020), we have made this offering a completely online offering.

**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.


**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 | |