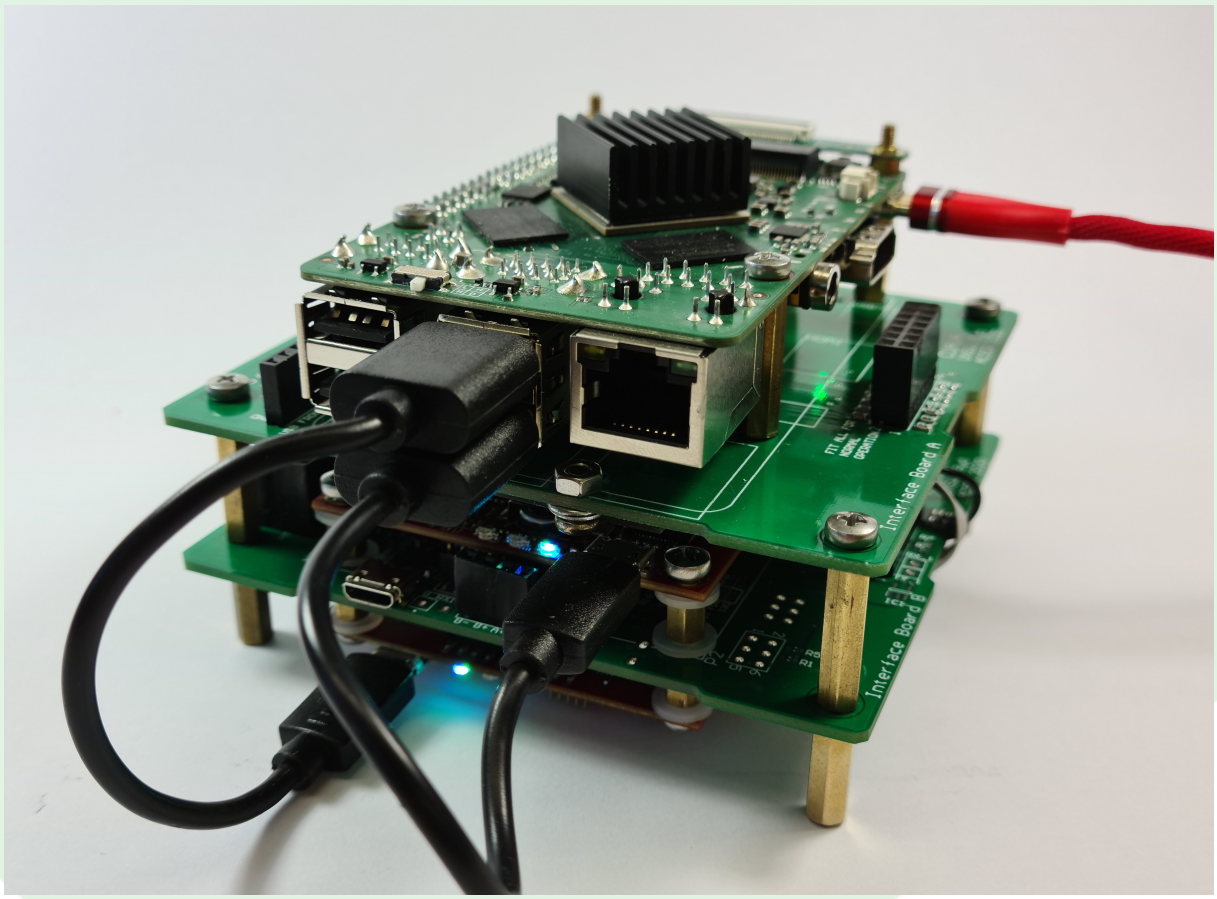
ELEC9725

Satellite Navigation: Systems, Signals & Receivers

Term 1, 2022



Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Andrew Dempster	a.dempster@unsw.edu.au	-	G17 409	56890

School Contact Information

Consultations: Lecturer consultation times will be advised during the first lecture. You are welcome to email the tutor or laboratory demonstrator, who can answer your questions on this course and can also provide you with consultation times. ALL email enquiries should be made from your student email address with ELEC/TELExxxx 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 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.

Student Support Enquiries

For enrolment and progression enquiries please contact Student Services

Web

Electrical Engineering Homepage

Engineering Student Support Services

Engineering Industrial Training

UNSW Study Abroad and Exchange (for inbound students)

UNSW Future Students

Phone

(+61 2) 9385 8500 – Nucleus Student Hub

(+61 2) 9385 7661 – Engineering Industrial Training

(+61 2) 9385 3179 – UNSW Study Abroad and UNSW Exchange (for inbound students)

Email

Engineering Student Support Services – current student enquiries

- e.g. enrolment, progression, clash requests, course issues or program-related queries

Engineering Industrial Training – Industrial training questions

UNSW Study Abroad – study abroad student enquiries (for inbound students)

UNSW Exchange – student exchange enquiries (for inbound students)

UNSW Future Students – potential student enquiries

- e.g. admissions, fees, programs, credit transfer

Course Details

Units of Credit 6

Summary of the Course

This course introduces the electronic and signal processing aspects of Global Positioning System (GPS) and other satellite navigation systems e.g. Galileo, GLONASS. The following topics are covered in the course: signal specifications for GPS L1, L2C and L5, GLONASS and Galileo signals, introduction to CDMA, frequency plan implications of the new GNSS signals, calculating a position, problems receiver designers must overcome (multipath, interference etc.), front-end RF design, correlator principles and approaches, signal acquisition/reacquisition, how measurements are made, receiver interfaces, augmentation systems (e.g. EGNOS, WAAS), Software Radio, weak signal and Assisted GPS and Interference. These principles will be illustrated using Matlab, allowing students to develop algorithm components of receivers.

Course Aims

The aim of the course is to provide an introduction to GPS and other satellite navigation systems, their signals and how they are processed to provide a position in a receiver. The course also provides details about GPS vulnerability and augmentation systems.

Course Learning Outcomes

After successfully completing this course, you should be able to:

Learning Outcome	EA Stage 1 Competencies
1. Understand and explain how satellite navigation systems work and how they interact with each other	PE1.1, PE1.2, PE1.3, PE1.4, PE1.5, PE1.6, PE2.1, PE2.2, PE2.3, PE3.2, PE3.3
2. Understand and explain the workings of a satellite navigation receiver in terms of the signal design and why it has that design, and receiver subsystems and their functions in processing those signals	PE1.1, PE1.2, PE1.3, PE1.4, PE1.5, PE1.6, PE2.1, PE2.2, PE2.3, PE3.2, PE3.3
3. Select appropriate subsystems (e.g. antenna, RF front end) for a GPS receiver design	PE1.1, PE1.2, PE1.3, PE1.4, PE1.5, PE1.6, PE2.1, PE2.2, PE2.3, PE3.2, PE3.3
4. Make sound decisions about a GPS solution for integration within a larger system, based on your knowledge of how GPS components affect performance,	PE1.1, PE1.2, PE1.3, PE1.4, PE1.5, PE1.6, PE2.1, PE2.2, PE2.3, PE3.2, PE3.3
5. Make an educated selection of GNSS receiver from those receiving GPS, Glonass, WAAS, Galileo, QZSS signals on the L1, L2, L5, E5 and E6 frequencies.	PE1.1, PE1.2, PE1.3, PE1.4, PE1.5, PE1.6, PE2.1, PE2.2, PE2.3, PE3.2, PE3.3

Teaching Strategies

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

- Lectures (pre-recorded with live questioning) provide you with a focus on the core analytical material in the course, together with qualitative, alternative explanations to aid your understanding. These lectures are particularly interactive and all attendees will be required to participate;
- “Laboratories”, which are only for those who are unfamiliar with Matlab. They are hands-on and allow for exercises in problem-solving and allow time for you to resolve problems in understanding of lecture material;
- Tutorials, which are specifically aimed to prepare students for the assessed assignments, and provide feedback on the assignments completed;
- Demonstrations to clarify with real examples how material covered in the lectures works in practice.

The lectures are stand-alone and cover one specific topic. The lectures are ordered such that there is a general introduction to satellite navigation, then the definition of the signals to be processed, then the processing of those signals in the order in which the receiver performs the processing. Matlab tutorials give the student sufficient background to complete the Matlab-based assignments. The assignments themselves are aimed to give students experience of the material covered in lectures, to allow “learning by doing”. Demonstrations of receivers and visualisation software bring the theoretical discussions to life. Regular quizzes ensure the student is up to date with the lecture material.

Learning in this course
You are expected to attend 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, the most important of which is the Kaplan textbook. If the student was to buy one textbook, this one is recommended. 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.

Assessment

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. Final Quiz	30%	Not Applicable	1, 2, 3, 4, 5
2. In-class quizzes	10%	Not Applicable	1, 2, 3, 4, 5
3. Assignments	60%	Not Applicable	1, 2, 3, 4, 5

Assessment 1: Final Quiz

Assessment length: 2 hours

Multiple choice

Assessment 2: In-class quizzes

4 quizzes throughout the semester. Multiple choice

Assessment 3: Assignments

3 Assignments: 1. Create a signal 15%; 2. Process a signal 20%; 3. Presentation 25% Each requires a report. The first two require a Matlab program, the third an in-class presentation

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

Course Schedule

View class timetable

Timetable

Date	Type	Content
Week 1: 14 February - 18 February	Lecture	Introduction to Radionavigation Introduction to GPS GPS Signal Specification
Week 2: 21 February - 25 February	Lecture	Navigation Message Positioning Principles *GPS Rx Demo*
Week 3: 28 February - 4 March	Lecture	Positioning Errors Datums
	Assessment	**Quiz 1** **(Assignment 1 available)**
Week 4: 7 March - 11 March	Lecture	Differential GPS Augmentation Systems
	Tutorial	**Assignment 1: Preparation**
Week 5: 14 March - 18 March	Lecture	Receiver Architectures RF Front End and Antennas Correlators
	Assessment	**Quiz 2** **(Assignment 1 due)**
Week 6: 21 March - 25 March	Lecture	Tracking Loops Real GPS Data Namuru

	Assessment	**(Assignment 2 available)**
Week 7: 28 March - 1 April	Lecture	Interference Weak Signal/ Assisted GPS
	Assessment	**Quiz 3**
	Tutorial	**Assignment 2: Feedback/Preparation**
Week 8: 4 April - 8 April	Lecture	Multi-GNSS GPS L2C/L5 Signals Galileo Signals and Receivers
	Assessment	**(Assignment 2 due)** **(Assignment 3 available)**
Week 9: 11 April - 15 April	Lecture	Glonass/ Beidou/ QZSS GNSS in Society
	Assessment	**Quiz 4**
	Tutorial	**Assignment 3: Feedback/Preparation**
Week 10: 18 April - 22 April	Assessment	**Assignment 3 Presentations** **(Assignment 3 due)**

Resources

Prescribed Resources

COURSE RESOURCES

Textbooks

Prescribed textbook

- Elliott D Kaplan and Christopher Hegarty, “Understanding GPS: Principles and Applications (2nd ed)”, Artech House, ISBN: 978-1-58053-895-4, 2005

Reference books

- James B-Y Tsui, “Fundamentals of Global Positioning Receivers: A Software Approach (2nd ed)”, Wiley, ISBN: 978-0-471-70647-2, 2005
- Borre, K., Akos, D.M., Bertelsen, N., Rinder, P., Jensen, S.H. , “A Software-Defined GPS and Galileo Receiver: A Single-Frequency Approach”, Birkhäuser, ISBN: 978-0-8176-4390-4, 2007
- Bradford W. Parkinson, James J. Spilker Jr., “Global Positioning System: Theory and Applications”, vols I & II, American Institute of Aeronautics and Astronautics, ISBN: 978-1-56347-249-7, 1996

On-line resources

Moodle

As a part of the teaching component, Moodle will be used to disseminate teaching materials, host forums and provide news. 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).

Course Evaluation and Development

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 myExperience process. 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. Specifically with respect to 2020 feedback, assignment 1 has been made a group activity to increase student interaction.

Academic Honesty and Plagiarism

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.

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.

Academic Information

COVID19 - 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.

Dates to note

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

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.

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.

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

Image Credit

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CRICOS

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Acknowledgement of Country

We acknowledge the Bedegal people who are the traditional custodians of the lands on which UNSW Kensington campus is located.

Appendix: Engineers Australia (EA) Professional Engineer Competency Standard

Program Intended Learning Outcomes	
Knowledge and skill base	
PE1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline	✓
PE1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline	✓
PE1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline	✓
PE1.4 Discernment of knowledge development and research directions within the engineering discipline	✓
PE1.5 Knowledge of engineering design practice and contextual factors impacting the engineering discipline	✓
PE1.6 Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline	✓
Engineering application ability	
PE2.1 Application of established engineering methods to complex engineering 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	
Professional and personal attributes	
PE3.1 Ethical conduct and professional accountability	
PE3.2 Effective oral and written communication in 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	