

# TELE9753

Advanced Wireless Communications

Term 1, 2022



## Course Overview

### Staff Contact Details

#### Convenors

Name	Email	Availability	Location	Phone
Jinhong Yuan	<a href="mailto:J.Yuan@unsw.edu.au">J.Yuan@unsw.edu.au</a>	4-5 pm before class	EE 408	93854244

### 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 provides advanced knowledge of wideband wireless communication techniques to enable the students to design advanced wireless communication systems. It includes the topics of diversity techniques, multiple access and interference management, Wideband CDMA, Wideband OFDM, antenna arrays, multiple-input/multiple-output communications, spatial multiplexing, space-time processing and coding; and multiuser detection, opportunistic communication, multiuser waterfilling.

### Course Learning Outcomes

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

Learning Outcome	EA Stage 1 Competencies
1. Understand and explain the principles, algorithms and technologies, including diversity, interference averaging, interference management, successive interference cancellation, superposition modulation, etc, used in transmission information in wireless mobile channels	PE1.1, PE1.2, PE1.5, PE1.6, PE2.1
2. Derive expressions for error performance and capacity for various transmission schemes covered in the lectures, such as space-time coding, MRC, OFDM, CDMA	PE1.1, PE1.2, PE1.3, PE2.1
3. Explain the operation of example algorithms covered in lectures, and discuss the effects of varying parameter values within these (water-filling, channel inversion, MMSE, ZF)	PE1.2, PE1.6, PE2.1
4. Apply the principles and technique to communication systems design or undertake further research (case study based on allocated power, spectrum and users, QoS)	PE1.1, PE1.2, PE1.6, PE2.1, PE2.3

### Teaching Strategies

### Delivery Mode

The course consists of the following elements: lectures and tutorials, and home works. If possible we will introduce some lab session based on MATLAB software.

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;

## **Learning in this course**

You are expected to attend all lectures, tutorials, and mid-semester exams in order to maximise learning. You must prepare well for your laboratory classes and your lab work will be assessed. In addition to the lecture notes/video, you should read relevant sections of the recommended text. Reading additional texts will further enhance your learning experience. 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.

## **Tutorial classes**

You should attempt all of your 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. Answers for these questions will be discussed during the tutorial class and the tutor will cover the more complex questions in the tutorial class. In addition, during the tutorial class, 1-2 new questions that are not in your notes may be provided by the tutor, for you to try in class. These questions and solutions may not be made available on the web, so it is worthwhile for you to attend your tutorial classes to gain maximum benefit from this course.

## Assessment

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. Mid-session Exam	35%	Not Applicable	1, 2
2. Homework	15%	Not Applicable	1, 2, 3
3. Final Exam	50%	Not Applicable	1, 2, 3, 4

### Assessment 1: Mid-session Exam

The mid-session 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 course material up to the end of week 5 or 6. 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. This is related to learning outcomes 1 and 2.

### Assessment 2: Homework

The home work tests your general understanding of the course materials. It will be given for some specific chapters. Grades will be assigned according to the understanding of each question/exercise. This is related to learning outcomes 1, 2, and 3.

The lectures can only cover the course material to a certain depth; you must read the textbook(s) and reflect on its content as preparation for the lectures to fully appreciate the course material. Home preparation provides you with the background knowledge you will need. The problem sheets aim to provide in-depth quantitative and qualitative understanding of wireless communications theory and methods. Together with your attendance at classes, your self-directed reading, completion of problems from the problem sheet and reflection on course materials will form the basis of your understanding of this course.

### Assessment 3: Final Exam

The exam in this course is a standard closed-book 2 hour written examination, comprising four-to-six 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.

## Attendance Requirements

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

## Course Schedule

Period	Summary of Lecture Program
Week 1	<p><b>Introduction of wireless communications systems</b> (Chapter 1)</p> <p>Cellular Mobile Systems</p> <p>WiFi Systems</p>
Week 2	<p><b>Wireless Channels</b> (Chapter 2 pp. 10-42)</p> <p>Wireless Propagation, Channel fading, Large-scale fading and small-scale fading</p> <p>Channel Coherence time and channel coherence bandwidth</p> <p>Frequency selective and time selective channels</p>
Week 3	<p><b>Time Diversity and Receive Diversity</b> (Chapter 3, pp. 49-70)</p> <p>Diversity concept, optimal combining, diversity gain, array gain, error performance analysis over fading channels</p> <p>Maximum-ratio combining, equal-gain combining, selection combining</p> <p>Receiver beamforming</p>
Week 4	<p><b>Transmit Diversity</b> (S.M. Alamouti, "A simple transmit diversity technique for wireless communications". IEEE Journal on Selected Areas in Communications vol. 16, no. 8: pp. 1451-1458. Oct. 1998.; B. Vucetic and J. Yuan, Space-Time Coding, 2003)</p> <p>Transmit beamforming, Space-time codes, Alamouti scheme</p>
Week 5	<p><b>Frequency Diversity</b> (Chapter 3 pp.</p>

	<p>49-70 and pp. 496-504)</p> <p>OFDM, Multicarrier Modulation, Frequency-domain equaliser, CDMA, Rake receiver</p>
Week 6	<p><b>Midterm Exam</b></p> <p><b>Interference Management Revision</b> (Chapter 4, pp.120-155)</p> <p>Multiple Access, frequency reuse, power control, cell/sector handoff, interference averaging</p>
Week 7	<p><b>Channel Capacity</b> (Chapter 5, pp. 166-216)</p> <p>AWGN channel capacity, capacity for fading channels,</p>
Week 8	<p><b>Capacity for wireless channels</b> (Chapter 5, pp. 166-216)</p> <p>Capacity with and without channel state information</p> <p>Outage capacity</p> <p>Water Filling</p>
Week 9	<p><b>Multiuser channels, Opportunistic Beamforming</b> (chapter 6, pp. 228-270, Sec. 6.1, 6.2, 6.6, 6.7)</p> <p>Multiuser channels for uplink and downlinks</p> <p>Successive interference cancellation (SIC) and capacity region</p> <p>Multiuser Opportunistic Communication</p> <p>Multiuser Diversity</p> <p>Proportional fairness scheduling</p>
Week 10	<p><b>MIMO and multiuser systems</b> (chapter 7, pp. 290-328)</p>



MIMO channels

MIMO capacity with water filling and  
Singular value decomposition

Multuser MIMO

Angular resolution

## Resources

### Prescribed Resources

#### Textbooks

##### Prescribed textbook

The following textbook is prescribed for the course:

[1] David Tse and Pramod Viswanath, *Fundamentals of Wireless Communication*, Cambridge University Press, 2005.

[2] Andrew Goldsmith, *Wireless Communications*, Cambridge University Press, 2005.

You may need to check the coverage of this text before purchasing, as some topics in the syllabus are not featured. Unfortunately there is no single text that covers all topics in a satisfactory depth. Additional references, listed below and at the end of some lecture note sets, will in combination provide complete coverage of the course. Lecture notes will be provided, however note that these do not treat each topic exhaustively and additional reading is required.

#### Reference books

The following books are good additional resources for MIMO topics:

[3] B. Vucetic and J. Yuan: *Space-time coding: John Wiley and Sons*, 2003

#### 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>.**

##### Teams

**As a part of the teaching component, Teams will be used to teaching platform.**

## **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).

## **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>

## CRICOS

CRICOS Provider Code: 00098G

## 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	