School of Electrical Engineering and Telecommunications

Semester 1, 2018
Course Outline

ELEC/TELE9753
Advanced Wireless

COURSE STAFF

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Tutor:
Laboratory Contact:

Consultations: You are encouraged to ask questions on the course material, after the lecture class times in the first instance, rather than via email. Lecturer consultation times will be advised during lectures. 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/TELE9753 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.

COURSE SUMMARY

Contact Hours

The course consists of 3 hours per week, comprising lectures and tutorials (a typical class includes 2 hours of lecture and 1 hour of tutorial).

	Day	Time	Location
Lectures	Tuesday	6pm - 8pm	CivEng G1
Tutorials	Tuesday	8pm – 9pm	CivEng G1

Context and Aims

This course provides comprehensive and advanced knowledge of broadband wireless communication techniques. It includes wireless channel characteristics and modeling, modern diversity techniques (e.g., time diversity, space diversity, frequency diversity), error control coding and decoding, equalization, antenna arrays, multiple-input/multiple-output channel modeling in the angular domain and statistical models, smart antennas techniques, multiple-input/multiple-output communications systems, spatial multiplexing, space-time processing and coding, multiuser detection and receiver designs, multiple access and interference management, cooperative relaying, opportunistic communications, and multiuser water-filling.

This course provides comprehensive and advanced knowledge of broadband wireless communication systems. It includes the areas of:

- Diversity: Time diversity, Space diversity, Frequency diversity
- Coding and decoding
- Equalization
- Smart antennas techniques
- Multiuser detection and receiver designs

Indicative Lecture Schedule

Week	Lecture	Ref
1	Introduction	[1,2]
2	Wireless Channel	[1,2]
3	Time Diversity and Receive Diversity	[1,2]
4	Transmit Diversity	[1,2]
5	Frequency Diversity	[1,2]
6	Interference Management	
7	Mid-session examination, duration 1-1.5 hours Channel Coding	
8	Channel Capacity	[1,2]
9	Capacity for wireless channels	[2,3]
10	Multiuser channels	[1,2]
11	Opportunistic Beamforming	[2,3]
12	MIMO and multiuser systems	[2,3]

Assessment

Home work:	20%
Mid-session exam:	30%
Individual project:	0%
Final examination:	50%

Course Details

Credits

This is a 6 UoC course and the expected workload is 10–12 hours per week throughout the 13 week semester.

Relationship to Other Courses

This is a postgraduate course in the School of Electrical Engineering and Telecommunications. This course provides advanced knowledge of broadband wireless communication techniques to enable students to design advanced wireless communication systems. It includes the topics of diversity techniques, multiple access and interference management, coding and decoding, equalization, antenna arrays, multiple-input/multiple-output communications, spatial multiplexing, space-time processing and coding, multiuser detection, opportunistic communication, and multiuser water-filling. It serves as an excellent basis from which to commence research in the area. Various aspects of the course bring students up to date with the very latest developments in the field, as seen in recent international conferences and journals, and some of the laboratory work is designed in the style of

an empirical research investigation. TELE9753 is also well complemented by ELEC9754 Coding and Information Theory, which gives an insight into advanced knowledge of error control coding technique and theories of information transmission mainly at the physical layer. It is recommended for future study.

Pre-requisites and Assumed Knowledge

The minimum pre-requisite for the course is TELE3113, Analogue and Digital Communications (or equivalent). Knowledge from TELE4651 and TELE4653 is highly desirable.

It is essential that students are familiar with digital communications, modulation/demodulation, channel coding/decoding, matched filter receiver, coherent and non-coherent detections, random signals and processing, fading channels, bit error rate analysis. Students who are not confident in their knowledge from previous digital communications courses (especially the topics mentioned) are strongly advised to revise their previous course materials as quickly as possible to avoid difficulties in this course.

Learning outcomes

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

1. Derive expressions for error performance and capacity for various transmission schemes covered in the lectures, such as space-time coding, MRC, OFDM, CDMA.
2. 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);
3. Apply the principles and technique to communication systems design or undertake further research (case study based on allocated power, spectrum and users, QoS)

The course delivery methods and course content address a number of core UNSW graduate attributes; these include:

a. The capacity for analytical and critical thinking and for creative problem-solving, which is addressed by the tutorial exercises and laboratory work.
b. The ability to engage in independent and reflective learning, which is addressed by tutorial exercises together with self-directed study.
c. The skills of effective communication, which are addressed by the viva-style verbal assessment in the laboratory.
d. Information literacy, which is addressed by the homework.

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

This course provides comprehensive and advanced knowledge of broadband wireless communication techniques. It includes wireless channel characteristics and modeling, modern diversity techniques (e.g., time diversity, space diversity, frequency diversity), error control coding and decoding, equalization, antenna arrays, multiple-input/multiple-output channel modeling in the angular domain and statistical models, smart antennas techniques, multiple-input/multiple-output communications systems, spatial multiplexing, space-time processing and coding, multiuser detection and receiver designs, multiple access and interference management, cooperative relaying, opportunistic communications, and multiuser water-filling..

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 face-to-face 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

Home work:	20%
Mid-session exam:	30%
Individual project:	0 %
Final examination:	50%

The assessment scheme in this course reflects the intention to assess your learning progress through the semester.

Home work:

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.

Mid-session examination:

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 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.

Individual project:

The project examination tests your general understanding of a particular technique and its performance in wireless communications, which you have studied in the course material up to the end of week 7. The project is usually given in Week 6 or 7, lecture time. You need to hand-in before week 11. Late reports will attract a penalty of 10% per day (including weekends). Grades will be assigned according to the project report, results, discussions, programs. This is related to learning outcomes 1, 2, and 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. 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	a	b	c	d
Homework	✓	✓	-	✓	✓	✓	-
Mid-semester exam	-	✓	✓	-	✓	✓	✓
Assignment	✓	✓	✓	-	✓	-	-
Final exam	-	✓	✓	✓	✓	-	✓

Course 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

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

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/guide), and particular attention is drawn to the following:

Workload

It is expected that you will spend at least ten to twelve hours per week studying a 6 UoC course, from Week 1 until the final assessment, including both face-to-face classes and independent, self-directed study. In periods where you need to 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 should seek assistance early if you suffer illness or misadventure which affects your course progress. All applications for special consideration must be **lodged online through myUNSW within 3 working days of the assessment**, not to course or school staff. For more detail, consult 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 Course and Teaching Evaluation and Improvement 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.

Tutorial questions have been changed in response to previous feedback.

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:

http://www.engineering.unsw.edu.au/electrical-engineering/policies-and-procedures

https://my.unsw.edu.au/student/atoz/ABC.html

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 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	