School of Electrical Engineering & Telecommunications
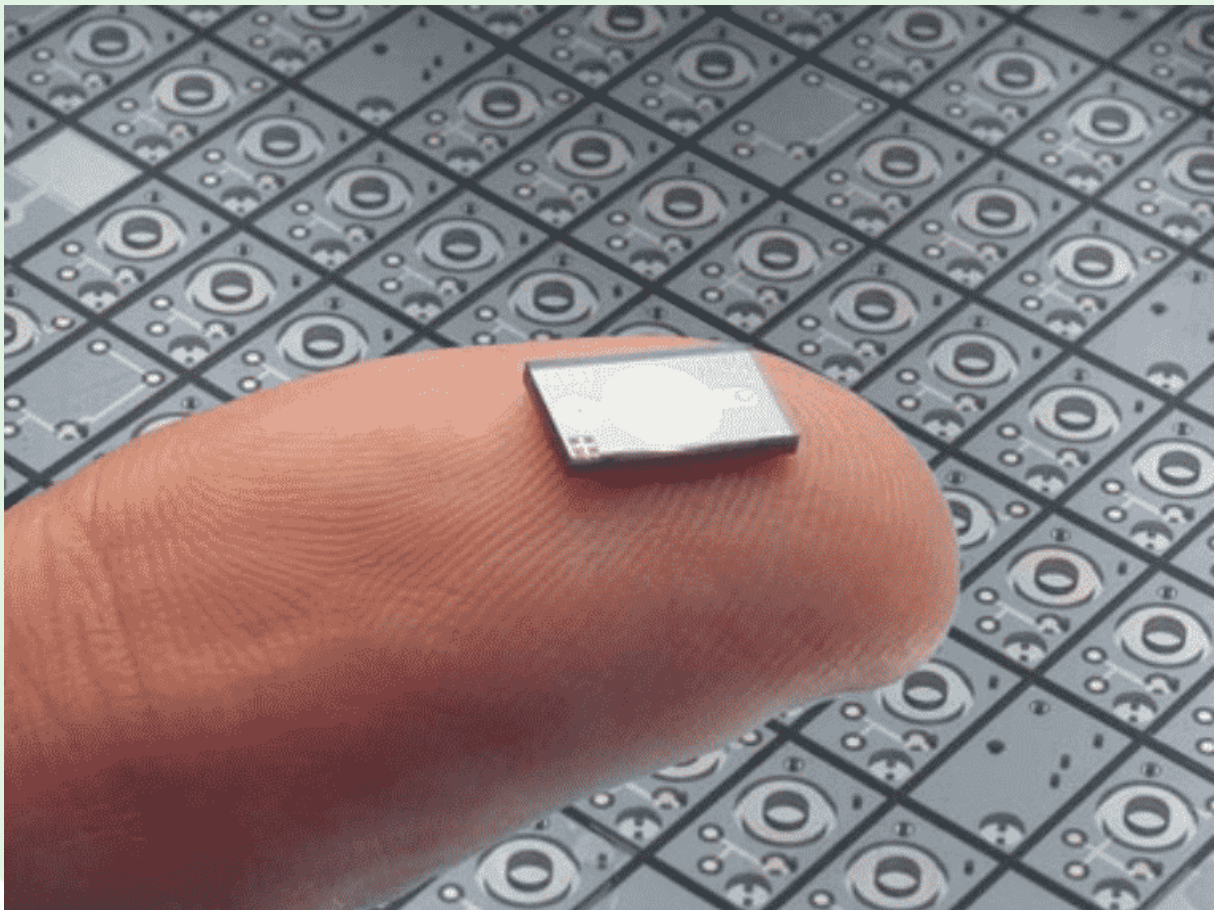
UNSW Engineering

ELEC9703

Microsystems Design and Technology

Term 1, 2022

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Aron Michael	a.michael@unsw.edu.au	Thursday 5-6pm	G17, 316	93855663

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

Microsystems technology is multidisciplinary in nature. It is also known as MEMS (Micro-Electro-Mechanical Systems) technology. The most important disciplines that intersect with Microsystems work are electrical engineering, mechanical engineering, microelectronic engineering, physics, material science, chemistry, fluidic engineering, photonics, biomedical engineering, biosciences etc. MEMS is truly an enabling technology which has penetrated into and begun to change the way major discipline do things, including biotechnology, storage technology, instrumentation, telecommunications, optical communications, Integrated Circuits and MEMS device packaging, medical technology etc. MEMS research, engineering development and modern manufacturing processes require close integration and collaborative interaction of experts from many disciplines. On the other hand MEMS researchers and engineers must be willing to cross interdisciplinary boundaries and acquire knowledge outside their discipline of expertise. Examples of MEMS devices produced in large volumes include, pressure sensors, flow sensors, inertial measurement units(IMU) like accelerometers and gyroscopes, micro-valves and micro-pumps, projection display chips, biosensors, inkjet nozzle arrays, optical cross-switches, RF switches, Lab on a Chip, etc., etc.

In short, this course will cover a wide range of topics related to MEMS fabrication technology and expand on to some of the design issues, bearing in mind the technology constraints. Can it be manufactured?! It will include examples of the design and fabrication of physical sensors like gyroscopes, accelerometers, etc. Furthermore, a course is not complete if we do not know what the current market drivers are for MEMS products and where the future holds for this exciting and fast expanding technology. Many people do not realise that the numerous savvy features we have in our mobile smart devices stem from advances in MEMS technology.

The subject will enable students to have a broad grasp of the multi-disciplinary nature of MEMS technology, bringing together the know-how of physicist, chemist, electrical and mechanical engineers, and mathematicians. It will provide the fundamental knowledge for students, who want to enter the MEMS industry. It is an exciting field of research and we should count ourselves fortunate to be witnessing and participating in this era of unparalleled technology advancement

Contact Hours

This postgraduate course consists of 3 hours of lectures every week. Problem discussions are included in the lectures and will not be treated as separate tutorials. The lectures will be recorded, and students can refer to them at a later date. Note that this is not a replacement for lecture attendance. Furthermore, some of the topics will be covered by pre-recorded lectures. Students will be notified as to when these recorded lectures will be available as the course progresses. Please note that materials covered in the pre-recorded lectures are also examinable. Lectures Day Time Location Thursday 6-9pm Online using Microsoft Teams CLS-ELEC9703_T1_5213_7238

Context

The entire field of research in microsensors and microactuators has evolved at an exceedingly rapid pace over the past 35 years. It is often referred to as MEMS (MicroElectroMechanical Systems) or Microsystems Technology. Signals from the physical world around us are always in analog form. Yet, much of the signal processing is done in digital form by microelectronic circuits. Microsensors and

microactuators are the interfaces between the digital electronic domain and the physical world. Sensors and actuators in various forms have been around for centuries but significant miniaturisation was not possible until the last few decades due to the significant technological advances in microfabrication techniques. In many cases, these new devices bring along new advantages over the traditional components like several orders of magnitude in size reduction, new functionality, and possibly integration of on-chip signal processing circuit (smart sensors/actuators). Many of the micro-fabrication techniques originate from the wealth of processes developed for the fabrication of integrated circuits. Yet, the MEMS business cannot be simply compared to the IC(Integrated Circuits) business. ICs deal with electrical signals whereas MEMS devices are interfaces to the physical world, to and from the electrical domain. As such, one would expect a more diverse, a more complicated overall environment, interacting effectively and accurately between the electronic domain and the outside world. The natural outcome of this is the vast and diverse range of MEMS devices. In fact, if one word were to be used to characterize the field of MEMS or Microsystems, it would be its multidisciplinary nature. The most important disciplines needed for Microsystems work are electrical engineering, mechanical engineering, microelectronic engineering, physics, material science, chemistry, fluidic engineering, photonics, biomedical engineering, biosciences etc. MEMS is truly an enabling technology which has penetrated into and begun to change the way major discipline do things, including biotechnology, storage technology, instrumentation, telecommunications, optical communications, MEMS device packaging, etc. etc. MEMS research, engineering development and manufacture must require close integration and collaborative interaction of experts from many disciplines. On the other hand MEMS researchers and engineers must be willing to cross interdisciplinary boundaries and acquire knowledge outside their discipline of expertise. Examples of MEMS devices produced on large volumes include, pressure sensors, accelerometers, micro-valves, micro-pumps, projection display chips, biosensors, inkjet nozzle arrays, optical cross-switches, RF switches, Lab-on-chip etc.

Course Aims

The course aims to expose students to the MEMS fabrication technology and the design approaches, and enable them to appreciate the many advances in the technology that has become the 'enabling technology' for many other disciplines. It is also the aim of the course to highlight the multidisciplinary nature of the course and its impact on design issues.

Course Learning Outcomes

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

Learning Outcome	EA Stage 1 Competencies
1. Understand and explain a range of technologies used for micro-fabrication.	PE1.1, PE1.2, PE1.3
2. Understand and explain the principle of operations of microsensors and micro-actuators	PE1.1, PE1.2, PE1.3
3. Analyse and design micro-sensors and micro-actuators.	PE1.1, PE1.2, PE1.3, PE1.4, PE1.5, PE2.1, PE2.2, PE2.3, PE3.1, PE3.2, PE3.3

Learning Outcome	EA Stage 1 Competencies
4. Understand and explain the design flow procedure for MEMS devices.	PE1.3
5. Use ANSYS simulation.	PE1.5, PE2.1, PE2.2, PE2.3, PE3.1, PE3.2, PE3.3
6. Devise process flow to micro-fabricate MEMS devices.	PE1.2, PE1.3, PE1.5, PE2.1, PE2.2, PE2.3, PE3.1, PE3.2, PE3.3
7. Appreciate the multi-disciplinary nature of Microsystems.	PE1.3, PE3.2

Teaching Strategies

Delivery Mode

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

- Formal online lectures, which provide you with a focus on the core analytical material in the course, together with qualitative, alternative explanations to aid your understanding;
- There are no separate tutorials but done lectures from time to time. Some self-paced exercises will be given out in class during the course.
- Lectures will be recorded and available on Microsoft Stream after the online Teams lecture. It is not a substitute for missed lectures.

Learning in this course

You are expected to attend all online lectures, and attempt assignments in order to maximise learning. In addition to the lecture notes/video, you should read relevant sections of the recommended reference 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 online classes throughout the course.

Tutorial classes

There are no separate tutorial classes.

Laboratory program

There are no formal laboratory classes. However, a two-hour computer simulation laboratory session as an introduction to ANSYS will run in week 7 from 7-9pm.

Assignments:

There are two compulsory written assignments for this course, which will be released on the course Moodle in Week 3 and 7, respectively. The assignments will each be worth 12.5% of the overall mark in total for this course. It is expected that the students complete assignments on their own. Plagiarism will not be tolerated. Assignment submission dates are set on Mondays in week 7 and 10 for each assignment, respectively.

Mid-session exam:

A mid-session exam will be conducted on Monday of week 7 starting at 4:30- 6:00pm. Location for the exam will be announced during the course. Note: it will be conducted outside of the normal class lecture times of 6-9pm. It will be a open book exam. Students are strongly advised to take the mid-session exam seriously as it contributes 20% to the overall marks of the course.

Final exam:

It will be an open book of 2 hour final exam.

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

Mid-session and Final Exams

The mid-session exam in this course are open-book written examination so is the final exam. 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, unless specifically indicated otherwise by the lecturer. Further details will be given during the lectures. Marks will be assigned according to the correctness of the answers and not the volume of written material in the answer scripts.

Additional Course Information

Credits

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

Relationship to Other Courses

This is a postgraduate course offered to students in the Master of Engineering Science (8338) and Master of Engineering Coursework (8621) in the Faculty of Engineering at the University of New South Wales.

Pre-requisites and Assumed Knowledge

There is no specific pre-requisite for the course. However, it will be beneficial for students who are familiar with semiconductor technology which is covered in ELEC9704. It is further assumed that the students are familiar with some basic chemistry, physics, mechanics, electrical engineering etc. The course is very multidisciplinary in nature and students are challenged to do this course with an open mind to learn, be creative and innovate.

Syllabus

Introduction to Microsystems: an overview and trends ; Lithography and Thin Film Processes ; Surface micromachining ; Bonding Processes; High Aspect Ratio Micromachining (HARM); Mechanics: Properties of materials, structures, energy methods ; Actuation mechanisms: Electrostatic, Electromagnetic, Electrothermal, and Piezo-electric ; Lumped modelling with circuit elements and system dynamics ; Introduction to ANSYS Simulation: Electro-thermal, Piezoelectric and Electrostatic ; Optical

MEMS, Microfluidic basics and Bio-MEMS..

Assessment

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. Final Examination	50%	Not Applicable	1, 2, 3, 4, 7
2. Mid-session exam	25%	Not Applicable	1, 2, 3, 4, 7
3. Assignment 2	13%	24/04/2022 12:00 PM	1, 2, 3, 4, 5, 6, 7
4. Assignment 1	12%	27/03/2022 12:00 PM	1, 2, 3, 4, 6

Assessment 1: Final Examination

Final exam held during formal examination period.

Assessment 2: Mid-session exam

Mid-session exam has two parts: (a) weekly quizzes (5%); (b) mid-term exam (20%). The mid-term exam will be held in week 7.The weekly quizzes are online quizzes that run before every class and start in week 2. The weekly quiz will be opened from 5:30pm before every class and closed 6:10pm on the same day. The quiz will be drawn from the lecture covered in the previous week. It is multiple choice and should be done in less than 10mins.

Assessment criteria

The mid-term exam in this course is open-book written examination. 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 that are covered in the first six weeks, unless specifically indicated otherwise by the lecturer. Further details will be given during the lectures. Marks will be assigned according to the correctness of the answers and not the volume of written material in the answer scripts.

Additional details

A mid-term exam will be conducted on Monday of week 7 starting at 4:30- 6:00pm. Location for the exam will be announced during the course. Note: it will be conducted outside of the normal class lecture times of 6-9pm. It will be a open book exam. Students are strongly advised to take the mid-session exam seriously as it contributes 20% to the overall marks of the course.

Assessment 3: Assignment 2

Due date: 24/04/2022 12:00 PM

Written assignment 2 due Week 10 (12.5%)

Assessment criteria

There are two compulsory written assignments for this course, which will be released on the course Moodle in Week 3 and 7, respectively. The assignments will each be worth 12.5% of the overall mark in

total for this course. It is expected that the students complete assignments on their own. Plagiarism will not be tolerated. Assignment submission dates are set on Mondays in week 7 and 10 for each assignment, respectively.

Assessment 4: Assignment 1

Due date: 27/03/2022 12:00 PM

Written assignment 1 due Week 7

Assessment criteria

There are two compulsory written assignments for this course, which will be released on the course Moodle in Week 3 and 7, respectively. The assignments will each be worth 12.5% of the overall mark in total for this course. It is expected that the students complete assignments on their own. Plagiarism will not be tolerated. Assignment submission dates are set on Mondays in week 7 and 10 for each assignment, respectively.

Additional details

There are two compulsory written assignments for this course, which will be released on the course Moodle in Week 3 and 7, respectively. The assignments will each be worth 12.5% of the overall mark in total for this course. It is expected that the students complete assignments on their own. Plagiarism will not be tolerated. Assignment submission dates are set on Mondays in week 7 and 10 for each assignment, respectively.

Attendance Requirements

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

Course Schedule

[View class timetable](#)

Timetable

Date	Type	Content
O-Week: 7 February - 11 February		
Week 1: 14 February - 18 February	Lecture	Introduction to Microsystems: an overview and technology trends. Lithography
Week 2: 21 February - 25 February	Lecture	Thin Film Processes
Week 3: 28 February - 4 March	Lecture	Bulk Silicon Micromachining
	Assessment	Assignment 1 will be released on Moodle
Week 4: 7 March - 11 March	Lecture	Surface Micromachining High Aspect Ratio Micromachining (HARM)
Week 5: 14 March - 18 March	Lecture	Mechanics: Properties of materials, structures, energy methods
Week 6: 21 March - 25 March	Online Activity	Bonding techniques
Week 7: 28 March - 1 April	Lecture	Lumped modelling with circuit elements and system dynamics
	Assessment	Assignment 1 due
	Workshop	ANSYS workshop
	Assessment	Mid-term exam will be held on Thursday from 5-6pm on Moodle.
Week 8: 4 April - 8 April	Lecture	Actuation mechanisms: Electrostatic, Electromagnetic, Electrothermal and Piezo-electric. Case studies
Week 9: 11 April - 15 April	Lecture	Inertial sensors: Accelerometer, Gyroscopes,
Week 10: 18 April - 22 April	Lecture	pressure transducers, Optical MEMS; Bio MEMS
	Assessment	Assignment is due on Monday the following week

Resources

Prescribed Resources

Textbooks:

There is no textbook set for this course but a good reference book to buy is by JD Plummer or S Sze. The following are the recommended reference books. In the view of the wide range of disciplines in this course, there is no single textbook that appropriately covers all the course material. Hence, it does not have prescribed textbook. However, the following reference books and articles are recommended:

1. MJ Madou, "Fundamentals of Microfabrication", CRC Press (good text to buy)

2. GTA Kovacs, "Micromachined Transducers sourcebook," McGraw Hill, 1988.

3. S D Senturia, "Microsystems Design", KAP, 2001.

4. L. Ristic, "Sensor Tchnonology and Devices", AH, 1994.

5. P. Rai-Choudhury, "Microlithography, Micromachining, and Microfabrication", Vo..2, SPIE Press, 1997.

6. M Elwenspoek and HV Jansen, "Silicon Micromachining," CUP 1998.

7. SA Campbell, "The Science and Engineering of Microelectronics Fabrication"

8. S. SZE, "VLSI Technology", McGrawHill

9. Gere & Timoshenko, "Mechanics of Materials"

10. Roark, "Roark's Formula for Stress and Strain," McGrawHill, 6th Ed, 1989.

11. M Lambrechts &W Sansen, "Biosensor- Micorelectromechanical devices", IOP, 1992.

12. JW Gardner, "Microsensors", Wiley, 1994.

13. IEEE Journal of Micro-Electro-Mechanical Systems

14. Sensors and Actuators A: Physical

15. Journal of Micromechanics and Microengineering

16. Proceedings from Transducers conferences

17. Proceedings from IEEE MEMS conferences

18. Proceedings from EUROSENSOR conferences

19. Procedia Engineering

On-line resources

Moodle

As a part of the teaching component, Moodle will be used to disseminate materials, host forums: https://moodle.telt.unsw.edu.au/login/index.php. All information about this course is available from this link which is regularly updated. Mailing list Announcements concerning course information will be given 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

Image Credit

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	