UNSW AUSTRALIA

# Course outline

Semester 2 2016

Never Stand Still | Engineering | Mechanical and Manufacturing Engineering

## MECH9650

# Introduction to Micro Electromechanical Systems (MEMS)

# Contents

# 1. Staff contact details

**Contact details and consultation times for course convenor**

Dr Majid Ebrahimi Warkiani
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Email: m.warkiani@unsw.edu.au

All consultations are by appointment only

# 2. Course details

**Location and times**

- Wedesnday1800-2100, Electrical Eng G24 (K-G17-G24)

**Credit Points**

This is a 6 unit-of-credit (UoC) course, and involves three (3) hours per week (h/w) of face-to-face contact.

The UNSW website states “The normal workload expectations of a student are approximately 25 hours per semester for each UoC, including class contact hours, other learning activities, preparation and time spent on all assessable work. Thus, for a full-time enrolled student, the normal workload, averaged across the 16 weeks of teaching, study and examination periods, is about 37.5 hours per week.”

This means that you should aim to spend about 9 h/w on this course. The additional time should be spent in making sure that you understand the lecture material, completing the set assignments, further reading, and revising for any examinations.

**Summary of the course**

This course is a comprehensive introduction to the field of MEMS (MicroElectroMechanical Systems) or Microsystems Technology. We will discuss different methods and tools to create submicron devices ranging from microsensors to pressure gauges, gyroscopes, micro-needles, nano-filters and medical devices. Micro-technologies have been changing the faces of various technologies that we knew in the past. Their rapid development brings the human society a useful tool in the multidisciplinary research field. This course covers all essential topics including principles, designs, fabrications and applications. The course will serve as a corner stone and assist beginners to carry out their systems.

**Aims of the course**

This course introduces the fundamentals of Micro Electromechanical systems (MEMS) and its applications in a wide range of devices and systems, as well as the design and simulation of these systems. MEMS is an enabling technology which has been penetrated into and begun to change the way major discipline do things, including biotechnology, storage technology, instrumentation, optical communications, telecommunications, MEMS device packaging, etc.

This course provides an interdisciplinary overview of MEMS including the micro machining and fabrication technology, microfluidic basics and devices, BioMEMS and etc. Students will have a hands-on experience in modeling and designing of MEMS devices through group projects. Students are expected to complete a significant modeling application within the ANSYS/COMSOL environment. The School has unlimited site licenses for ANSYS. We might have the possibility of visiting Australian Nanofabrication Facility (ANFF) at UNSW too.

**Student learning outcomes**

This course is designed to address the learning outcomes below and the corresponding Engineers Australia Stage 1 Competency Standards for Professional Engineers as shown. The full list of Stage 1 Competency Standards may be found in Appendix A.

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

| **Learning Outcome** | | **EA Stage 1 Competencies** |
|---|---|---|
| 1 | Understand a range of technologies used in micro-machining and micro-fabrication | PE 1.3 |
| 2 | Execute a successful analysis of the MEMS problems of sufficient complexity to give insight into practical applications of the methods | PE 2.1, 2.2, 2.4 |
| 3 | Interpret results and write a report conveying the results of the analysis. | PE 2.1, 2.2, 3.2 |
| 4 | Model MEMS in commercial software packages such as ANSYS and COMSOL, and use the techniques, skills, and modern engineering tools necessary for engineering practice | PE 1.3, 1.1, 2.2 |
| 5 | Design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, health and safety, manufacturability, and sustainability | PE 1.4, 1.6, 2.1, 2.2, 2.3, 2.4 |

# 3. Teaching strategies

Ideas and skills are first introduced and demonstrated in lectures, and then students develop these skills by applying them to specific tasks through various assignments.

The lectures, delivered in class, will cover a range of Micro and Nano engineering topics. We will discuss about various techniques and approaches for fabrication of micro and nano systems (e.g., surface/bulk micromachining, MEMS materials, bonding processes, packaging, advanced wet/dry etching process, etc.). Computing skills are developed and practiced in regular computer laboratory sessions. This will give students proficiency in using the commercial packages such as ANSYS, COMSOL and FLUENT.

This course has a major focus on research, inquiry and analytical thinking as well as information literacy. We will also explore capacity and motivation for intellectual development through the solution of both simple and complex mathematical models of problems arising in engineering, and the interpretation and communication of the results.

# 4. Course schedule

| **MECH9650 Introduction to Micro Electromechanical Systems (MEMS)** | | |
|---|---|---|
| Week | Lecture (2 Hr.) | Problem solving (1 Hr.) |
| 1 | Introduction to MEMS/NEMS, BioMEMS and Biotechnology | Case studies |
| 2 | Fundamental of MEMS fabrication **I** | Case studies |
| 3 | Fundamental of MEMS fabrication **II** | *Homework # 1 to be released* |
| 4 | MEMS modelling and simulation using ANSYS, FLUENT and COMSOL | - |
| 5 | MEMS packaging, Nanofabrication and Soft-lithography | Group Project # 1 (3D Printing)<br><br>*Homework # 1 submission due by Friday, 26 Aug 2016* |
| 6 | Nano-scale: What's so special? | - |

| | | |
|---|---|---|
| 7 | Microfluidics I (Basic physics) | Project discussion and feedback<br><br>*Homework # 2 and* Group Project # 2 *to be released* |
| 8 | Microfluidics II (Microneedle, micromixers, other applications) | Case studies |
| 9 | Mechanics properties of materials and 3D Printing | *Homework # 2 submission due by Friday, 23 Sep 2016* |
| 10 | Micro/Nano-Biosensors (Basics and applications) | Case studies (submission of group project #1 report, Friday 14 Oct 2016) |
| 11 | Group project presentation # 1 | |
| 12 | Group project presentation # 2 | |
| 13 | Q&A (before final exam) | Feedback on Group assignments<br>*Group project# 2 submission due on Friday, 28 Oct 2016* |

# 5. Assessment

**General**

Many practical problems in Engineering require use of a computer software package, and student skills in software use applied to relevant problems are rewarded by the laboratory participation component of the overall grade. The final exam will assess student mastery of the material covered in the lectures and laboratory classes.

Final grades may be adjusted by scaling with the approval of the appropriate departmental meeting.

| Assessment | Weight | Learning outcomes assessed | Due date and submission requirements | Marks returned |
|---|---|---|---|---|
| Homework # 1 | 5% | 1,2 | due Week 5 (Friday, 26 August) by email | One week after submission |
| Homework # 2 | 5% | 1,2 | due Week 9 (Friday, 23 September) by email | One week after submission |
| Group project # 1 | 15% | 2,3 | due week 10 (Friday, 18 September) by email (group leaders) | Two weeks after submission |
| Group project # 2 | 15% | 2,3,4 | due week 13 (Friday, 28 October) by group leaders | After release of results |
| Project presentation | 15% | 3,4,5 | due week 11 and 12 in class | By request in stuvac |
| Examination | 45% | 1,2,3,4,5 | During exam period | After release of results |
| Total | 100% | | | |

**Home works**

During the semester, home works will be handed out and will be available on the UNSW Moodle website.

**Project Presentation**

All submissions should have a standard School cover sheet available on the School website at www.engineering.unsw.edu.au/mechanical-engineering/forms-and-guidelines.

All submissions are expected to be neat, and clearly set out. All calculations should be shown as, in the event of incorrect answers, marks are awarded for method and understanding.

The preferred set-out of any numerical calculation is similar to the following:

$\Delta = \rho\nabla$ (Equation in symbols)
$= 1.025 \times 200$ (Numbers substituted)
$= 205$ t (Answer with units)

**Submission**

Group projects and paper are due on the schedule depicted above. They are to be submitted in assignments boxes.

Late submissions will be penalised 5 marks per calendar day (including weekends). An extension may only be granted in exceptional circumstances. Where an assessment task is worth less than 20% of the total course mark and you have a compelling reason for being unable to submit your work on time, you must seek approval for an extension from the

course convenor ***before the due date***. Special consideration for assessment tasks of 20% or greater must be processed through student.unsw.edu.au/special-consideration.

It is always worth submitting late assessment tasks when possible. Completion of the work, even late, may be taken into account in cases of special consideration.

**Criteria**

Grading of group project and home works will be based on the following criteria:

For report-style assignments:

- Identification of key facts and integration of those facts in a logical development
- Clarity of communication – development of clear and orderly structure and highlighting of core arguments
- Sentences in clear, plain and concise English – correct grammar, spelling and punctuation
- Correct referencing in accordance with prescribed citation and style guide

For group project that involve numerical calculations:

- Accuracy of numerical answers and findings
- All working needs to be shown
- Use of diagrams to support or illustrate the calculations
- Use of graphs to support or illustrate the calculations
- Use of tables to support or illustrate the calculations

**Examinations**

There will be one two-hour examination at the end of the session.

You must be available for all tests and examinations. Final examinations for each course are held during the University examination periods, which are June for Semester 1 and November for Semester 2. Provisional Examination timetables are generally published on myUNSW in May for Semester 1 and September for Semester 2

For further information on exams, please see the Exams section on the intranet.

*Calculators*

You will need to provide your own calculator, of a make and model approved by UNSW, for the examinations. The list of approved calculators is shown at student.unsw.edu.au/exam-approved-calculators-and-computers

It is your responsibility to ensure that your calculator is of an approved make and model, and to obtain an “Approved” sticker for it from the School Office or the Engineering Student

Centre prior to the examination. Calculators not bearing an “Approved” sticker will not be allowed into the examination room.

**Special consideration and supplementary assessment**

For details of applying for special consideration and conditions for the award of supplementary assessment, see the School intranet, and the information on UNSW’s Special Consideration page.

## 6. Expected resources for students

***Main Text*:**

Lecture notes will be provided via Moodle

**Additional Reading:**

- SD Senturia, Microsystems Design Book
- Marc Madou, Fundamentals of Microfabrication: The Science of Book Miniturization.
- Nguyen N.T., Wereley S., 2006, Fundamentals and Applications of Microfluidics, Second Edition, Artech House, Boston, London.

## 7. Course evaluation and development

Feedback on the course is gathered periodically using various means, including the Course and Teaching Evaluation and Improvement (CATEI) process, informal discussion in the final class for the course, and the School’s Student/Staff meetings. Your feedback is taken seriously, and continual improvements are made to the course based, in part, on such feedback.

In this course, recent improvements resulting from student feedback include: 1- dedicated CFD session and troubleshooting, 2- Australia Nanofabrication (ANFF) facility tour, and 3- case studies for successful MEMS related projects.

## 8. Academic honesty and plagiarism

UNSW has an ongoing commitment to fostering a culture of learning informed by academic integrity. All UNSW students have a responsibility to adhere to this principle of academic integrity. Plagiarism undermines academic integrity and is not tolerated at UNSW. *Plagiarism at UNSW is defined as using the words or ideas of others and passing them off as your own.*

Plagiarism is a type of intellectual theft. It can take many forms, from deliberate cheating to accidentally copying from a source without acknowledgement. UNSW has produced a

website with a wealth of resources to support students to understand and avoid plagiarism: student.unsw.edu.au/plagiarism The Learning Centre assists students with understanding academic integrity and how not to plagiarise. They also hold workshops and can help students one-on-one.

You are also reminded that careful time management is an important part of study and one of the identified causes of plagiarism is poor time management. Students should allow sufficient time for research, drafting and the proper referencing of sources in preparing all assessment tasks.

If plagiarism is found in your work when you are in first year, your lecturer will offer you assistance to improve your academic skills. They may ask you to look at some online resources, attend the Learning Centre, or sometimes resubmit your work with the problem fixed. However more serious instances in first year, such as stealing another student's work or paying someone to do your work, may be investigated under the Student Misconduct Procedures.

Repeated plagiarism (even in first year), plagiarism after first year, or serious instances, may also be investigated under the Student Misconduct Procedures. The penalties under the procedures can include a reduction in marks, failing a course or for the most serious matters (like plagiarism in an honours thesis) even suspension from the university. The Student Misconduct Procedures are available here: www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf

Further information on School policy and procedures in the event of plagiarism is available on the intranet.

## 9. Administrative matters

All students are expected to read and be familiar with School guidelines and polices, available on the intranet. In particular, students should be familiar with the following:

- Attendance, Participation and Class Etiquette
- UNSW Email Address
- Computing Facilities
- Assessment Matters (including guidelines for assignments, exams and special consideration)
- Academic Honesty and Plagiarism
- Student Equity and Disabilities Unit
- Health and Safety
- Student Support Services

*M.E. Warkiani*
*July 2016*

# Appendix A: Engineers Australia (EA) Stage 1 Competencies for Professional Engineers

| | **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 |