



# Course Outline

Semester 2 2015

Never Stand Still

Engineering

Mechanical and Manufacturing Engineering

## **MECH9650**

# **Introduction to Micro Electromechanical Systems (MEMS)**

# Contents

1. Staff Contact Details .....	2
2. Course details .....	2
3. Teaching strategies.....	4
4. Course schedule .....	4
5. Assessment .....	5
6. Expected Resources for students.....	7
7. Course evaluation and development .....	7
8. Academic honesty and plagiarism.....	8
9. Administrative Matters.....	8
Appendix A: Engineers Australia (EA) Professional Engineer Competency Standards.....	9

# 1. Staff Contact Details

## Contact details for course convener

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All consultations are by appointment only

# 2. Course details

## Location and Times

- Thursday 1800-2100, Ainsworth Building 102 (K-J17-102)

## Credit Points:

This is a 6 unit-of-credit (UoC) course, and involves 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, electromagnetic, thermal actuation, 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.

## Student learning outcomes

This course is designed to address the below learning outcomes 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 Outcomes		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

<b>MECH9650 Introduction to Micro Electromechanical Systems (MEMS)</b>		
Week	Lecture (2 Hr.)	Problem solving (1 Hr.)
1	Introduction to MEMS/NEMS, BioMEMS and Biotechnology	-
2	Fundamental of MEMS fabrication I (Surface/Bulk micromachining, Soft-lithography, Process integration, LIGA, etc.)	Case studies
3	Fundamental of MEMS fabrication II (Packaging, characterization, Automation, etc.)	<i>Homework # 1 to be released</i>
4	MEMS modelling and simulation using ANSYS, FLUENT and COMSOL	-
5	Microscale physics	Group Project # 1
6	Microfluidics 1 (Fundamental, Micro-pumps, micro-valves, Micro-separators, micro-mixers, etc.)	Microfluidics exercise <i>Homework # 1 submission due by Friday, 3 Sept 2015</i>
7	Microfluidics 2 (Micro-mixers, microfilters, micro-valves, etc.)	Project discussion and feedback <i>Homework # 2 to be released and Group Project # 2 release</i>

8	Mechanics properties of materials and 3D Printing	
9	Micro and Biosensors (Basics and applications)	-
10	BioMEMS	Case studies (submission of group project #1 report, Wednesday 14 Oct 2015)
11	Group project presentation # 1	
12	Group project presentation # 2	
13	Q&A (before final exam)	Feedback on Group assignments <i>Group project# 2 submission due on Friday, 29 Oct 2015</i>

## 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 task	Weight	Due date and time	Learning outcomes assessed
Homework # 1	5%	due Week 4 (Friday, 21 August) in email	1,2
Homework # 2	5%	due Week 9 (Friday, 25 September) in email	1,2
Group project # 1	15%	due week 8 (Friday, 18 September) via School assignment boxes or email	2,3
Group project # 2	15%	due week 10 (Friday, 10 October) via School assignment boxes or email	2,3,4
Project presentation	15%	due week 11 and 12 in class	3,4,5
Examination	45%	TBA	1,2,3,4,5
<b>Total</b>	<b>100%</b>		

### 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](http://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:

$$\begin{array}{ll} \Delta = \rho \nabla & \text{(Equation in symbols)} \\ = 1.025 \times 200 & \text{(Numbers substituted)} \\ = 205 \text{ t} & \text{(Answer with units)} \end{array}$$

## 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 conveyor **before the due date**. Special consideration for assessment tasks of 20% or greater must be processed through <https://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

## Examination

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

You will need to provide your own calculator, of a make and model approved by UNSW, for the examination. The list of approved calculators is shown at

<https://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.

## 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 problem solving 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: <https://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:

<http://www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf>

Further information on School policy and procedures in the event of plagiarism is presented in a School handout, [Administrative Matters](#), available on the School website.

## 9. Administrative Matters

You are expected to have read and be familiar with [Administrative Matters for All Courses](#), available on the School website. This document contains important information on student responsibilities and support, including special consideration, assessment, health and safety, and student equity and diversity.

M.E. Warkiani  
July 2015

## Appendix A: Engineers Australia (EA) Professional Engineer Competency Standards

	<b>Program Intended Learning Outcomes</b>
<b>PE1: Knowledge and Skill Base</b>	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
<b>PE2: Engineering Application Ability</b>	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
<b>PE3: Professional and Personal Attributes</b>	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