UNSW SYDNEY | Australia's Global University

Mechanical and Manufacturing Engineering

# Course Outline

Term 3 2019

# MECH9650

# MICRO- AND BIOFLUIDICS

# Contents

# 1. Staff contact details

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

Name: Susann Beier
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Tel: (02) 9385 57580
Email: s.beier@unsw.edu.au
Consultation times: Mondays 8-9am in Susann's office or after the lecture.

Please come and see me in person if you have questions or post it on the forum for all students to learn.

Please see the course Moodle.

# 2. Important links

- Moodle
- Lab Access
- Computing Facilities
- Student Resources
- Course Outlines
- Engineering Student Support Services Centre
- Makerspace
- UNSW Timetable
- UNSW Handbook
- UNSW Mechanical and Manufacturing Engineering

# 3. Course details

**Credit Points**

This is a 6 unit-of-credit (UoC) course and involves 2 hours per week (h/w) of face-to-face contact.

The normal workload expectations of a student are approximately 25 hours per term for each UOC, including class contact hours, other learning activities, preparation and time spent on all assessable work.

You should aim to spend around 8 hours per week 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.

**Contact hours**

| | Day | Time | Location | Weeks |
|---|---|---|---|---|
| **Lectures** | Mondays | 5pm – 6pm | Chemical Sc M18 (K-F10-M18) | 1-3 and 5-11 |
| **Tutorial** | Mondays | 6pm – 7pm | Tyree Energy Technology G16 (K-H6-G16) | 1-3 and 6-10 |
| **Tutorial** | Mondays | 6pm – 7pm | Ainsworth 203 (K-J17-203) | 5 and 11 |

**Note: Due to Labour Day there will be no lecture or tutorials in week 4; instead we will have these in week 11.*

**Summary and Aims of the course**

This course introduces the fundamentals of micro- and biofluidics and its basic theory on fluid dynamics. We will learn about micro- and nanoscale fluidics devices and their fabrication as well as important modeling and experimental techniques used in relevant fields, especially biofluidics research.

The aim of the course is to give the students an insight into the research that can be conducted with micro- and biofluidic modelling and experiments. Starting with understanding special fluid properties that develop at micro- and nanoscale, all the way to predicting disease conditions in the human body and designing implants to prevent those conditions. A broad introduction into the field of micro and biofluidics is provided and students will learn about diversity and significance of the field.

**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. | Understanding the difference between macro- and microfluidics and how it is especially relevant to a range of biological systems | PE1.1-PE1.6 |
| 2. | Understanding how to fabricate a fluidics device using available school facilities by applying the theory learned | PE.1.5, PE.1.6, PE.2.1 |
| 3. | Learning how to compute fluidics problems by applying the techniques, skills and modern engineering tools learned | PE2.1-PE2.4 |
| 4. | Successfully design and analyze a microfluidics device of sufficient complexity to give insight into practical applications of the methods | PE2.1-2.4 |

| Learning Outcome | | EA Stage 1 Competencies |
|---|---|---|
| 5. | Present and discuss a device or component in this research space including its end-to-end fabrication, and its capability to meet desired need within realistic biological constraints such as economic, environmental, social, health and safety, manufacturability, and sustainability | PE3.1-3.6 |

# 4. Teaching strategies

| | |
|---|---|
| **Private Study** | – Review lecture material and notes<br>– Do set problems and assignments<br>– Reflect on class problems and assignments<br>– Practice the quizzes<br>– Keep up with notices and find out marks via Moodle<br>– Read and work with the provided material |
| **Lectures** | – Find out what you must learn<br>– Follow worked examples<br>– Hear announcements on course changes<br>– Ask questions |
| **Tutorial time** | – Be guided by demonstrators<br>– Follow worked examples<br>– Practice solving provided problems<br>– Work in a team<br>– Ask questions<br>– Practice a community of learning with your peers |
| **Practice questions** | – Reflect on your knowledge and skills<br>– Gain greater understanding and problem-solving ability |

# 5. Course schedule

| Week | Topic | Content | Lecture (1 hour) | Projects / Tutorials (1 hour) | Assessment |
|---|---|---|---|---|---|
| **Week 0**<br>Before<br>16 Sep | | | | • Familiarize yourself with Moodle – watch the introduction video, know which team you are in | |
| **Week 1**<br>16 Sep | Introduction | Introduction | • Susann introduction<br>• Demonstrator Intro<br>• Course outline<br>• LO<br>• Assessments<br>• Importance of the field | • Teams of 6-7 (22 total)<br>• Icebreaker<br>• Housekeeping | |
| **Week** 2<br>23 Sep | Theory | Macro fluidics | • Recap fundamentals of fluid mechanics<br>• Scale matters<br>• Intrinsic fluid properties<br>• Dimensionless numbers<br>• Types of macrofluidic flow<br>• Bernoulli's equation<br>• Macroscopic balance of mass and momentum | • Practice calculations<br>• Paper discussion<br>• Real life examples | |
| **Week** 3<br>30 Sep | | Micro fluidics | • Microscopic balance of mass and momentum<br>• Stokes flow / creeping flow<br>• Capillary flow<br>• Inertial flow<br>• Other microfluidic flow types<br>• Peclet number<br>• Dean number | • Practice calculations<br>• Paper discussion<br>• Real life examples | • Deliverable 1:<br>• Team based, make a paper-based microfluidics device, video (10%) - peer reviewed |
| **Week** 4<br>7 Oct | • *Week of Labour Day* | | | | |

| Week | Topic | Content | Lecture (1 hour) | Projects / Tutorials (1 hour) | Assessment |
|---|---|---|---|---|---|
| **Week** 5<br>15 Oct | | Bio-fluidics | • Wave propagation in arterial circulation<br>• Flow separation<br>• Flow through tapered and curved<br>• Turbulence and pulsate flow<br>• Flow in diseased arteries | • Look at highlights of the submitted videos, present best submissions | |
| **Week** 6<br>21 Oct | Fabrication | Fabrication techniques<br>GUEST LECTURE | • Macro, micro, nano and an introduction to their relevant fabrication methods<br>• Principal of domain coupling<br>• Fabrication principles – top-down and bottom up<br>• Packaging | | • Quiz 1 (40%) - on weeks 1 - 5 |
| **Week** 7<br>28 Oct | | Fabrication Applications – Micro and Biofluidic devices<br>GUEST LECTURE | • Four leading exciting applications / devices and their fabrication<br>Discussion of leading industry examples | • Micromixer introduction and discussion | |
| **Week** 8<br>4 Nov | • Optional FIELDTRIP to ANFF and Mechanical and Manufacturing 3D printing facilities | | | | |
| **Week** 9<br>12 Nov | Modelling and Experimental techniques | In silico | • Use CFD to describe flow through various physiological geometries<br>• Mathematics behind CFD (brief)<br>• Need for FSI<br>• Buckingham Pi Theorem to develop dimensionless numbers<br>• Dynamic similarity | • Micromixer CFD modelling<br>• Today's state of the art in silico biofluid mechanics research<br>• Possible future avenues of research | • Quiz 2 (20%) – on weeks 6 and 7 |
| **Week** 10<br>18 Nov | | In vitro | • Discuss common experimental techniques<br>• LAD<br>• PIV<br>• Parallel plate and other viscometer techniques | • Today's state of the art in vitro biofluid mechanics research<br>• Future avenues of research | • Deliverable 2: team based, Poster and Presentation on favorite microdevice/biodevice, their theory, application, importance (20%) - peer reviewed |
| **Week** 11<br>25 Nov | Summary | | • Course revision | • Review for deliverable 2<br>• Course feedback<br>• Closure | • *No final EXAM*<br>• 10% Class Contribution |

# 6. Assessment

## Assessment overview

| Assessment | Group Project? (# Students per group) | Length | Weight | Learning outcomes assessed | Assessment criteria | Due date and submission requirements | Deadline for absolute fail | Marks returned |
|---|---|---|---|---|---|---|---|---|
| Micro-fluidics device | Yes (7) | Video, 3 minutes | 10% | 2, 3, 4 and 5 | Peer reviewed, topics assessed include design, execution, analysis, complexity, and creativity | Week 3, Friday 5pm via Moodle | Week 4, Monday 5pm | 1 week after submission |
| Quizzes (2) | No | 45 minutes each | 60% (40% Q1 and 20% Q2) | 1 | Lecture materials from weeks 1-5 (Quiz 1) and 6-7 (Quiz 2) | Week 6 and 9 | N/A | The day after each quiz |
| Micromixer/fluidics system | Yes (2) | Virtual Conference - Recorded presentation and poster | 20% | 1, 2 and 3 | All course content from weeks 2-10 | Week 10, Friday 5pm via Moodle | Week 10, Monday 5pm | 1 week after submission |
| Class Contribution | No | Throughout the course | 10% | 1 - 5 | Lecture and tutorial participation, peer review | Marked throughout the course | N/A | End of term |

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**Assignments**

*Micro-mixer/ fluidics system - video*

The students will design and analyse a microfluidics paper-based device with freely available material and school resources. The students will undertake this in teams and will present their work in form of a video.

*Quizzes*

The students will be asked to calculate relevant problem scenarios and answer basic to complex questions to demonstrate their understanding of the difference between macro and microfluidics and their relevance for biological systems.

*Microfluidics device – visual conference*

The students will present a state of the art biofluidic problem and related fluidics device to meet a need and overcome a real-life problem. The teams of students can choose from a range of latest research to present, discuss and evaluate these devices.

*Field Trip*

Optional field trips will be available in week 8, which will be organized through expression of interests on a first come first basis and rostering during the lecturers. Unfortunately, it is not possible to provide a hand on experience for all students due to the large class size, however additional digital support material and a visual lab tour are also provided. Participation and interest may contribute towards a student's Class Contribution score.

**Assessment guidelines**

*Presentation*

All submissions are expected to be neat and clearly set out. Your results are the pinnacle of all your hard work and should be treated with due respect. Presenting results clearly gives the marker the best chance of understanding your method; even if the numerical results are incorrect.

*Submission*

Work submitted late without an approved extension by the course coordinator or delegated authority is subject to a late penalty of 20 per cent (20%) of the maximum mark possible for that assessment item, per calendar day.

The late penalty is applied per calendar day (including weekends and public holidays) that the assessment is overdue. There is no pro-rata of the late penalty for submissions made part way through a day.

Work submitted after the ‘deadline for absolute fail’ is not accepted and a mark of zero will be awarded for that assessment item.

For some assessment items, a late penalty may not be appropriate. These are clearly indicated in the course outline, and such assessments receive a mark of zero if not completed by the specified date. Examples include:

a. Weekly online tests or laboratory work worth a small proportion of the subject mark, or
b. Online quizzes where answers are released to students on completion, or
c. Professional assessment tasks, where the intention is to create an authentic assessment that has an absolute submission date, or
d. Pass/Fail assessment tasks.

*Marking*

Marking guidelines for assignment submissions will be provided at the same time as assignment details to assist with meeting assessable requirements. Submissions will be marked according to the marking rubrics provided.

*Quizzes*

Students are expected to bring their own laptop to classes. The quizzes will be done on the student’s own device during the tutorial time. Students can bring papers, pens and calculators to help solving some of the questions, however no other material is permitted. Students who are found to have other material close by will fail the quiz immediately.

**Examinations**

You must be available for all tests and an participate in group work. Substitute assessments may not be possible due to the nature of the assessment.

There will be no final exam.

*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 Engineering Student Supper Services Centre prior to the examination. Calculators not bearing an “Approved” sticker will not be allowed into the examination room.

**Special consideration and supplementary assessment**

If you have experienced an illness or misadventure beyond your control that will interfere with your assessment performance, you are eligible to apply for Special Consideration prior

to submitting an assessment or sitting an exam.

**Please note** that UNSW now has a Fit to Sit / Submit rule, which means that if you sit an exam or submit a piece of assessment, you are declaring yourself fit enough to do so and cannot later apply for Special Consideration.

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

## 7. Expected resources for students

Each student is expected to bring their own laptops to each lecture and tutorial. Please make sure you are able to use Microsoft Office and ANSYS CFD on your laptop which is available through MyAccess.

UNSW Library website: https://www.library.unsw.edu.au/
Moodle: https://moodle.telt.unsw.edu.au/login/index.php

## 8. Course evaluation and development

Feedback on the course is gathered periodically using various means, including the UNSW myExperience 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.

## 9. 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, visit: 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.

## 10. Administrative matters and links

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
- UNSW Email Address
- Computing Facilities
- Special Consideration
- Exams
- Approved Calculators
- Academic Honesty and Plagiarism
- Disability Support Services
- Health and Safety
- Lab Access

# Appendix A: Engineers Australia (EA) Competencies

*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 |