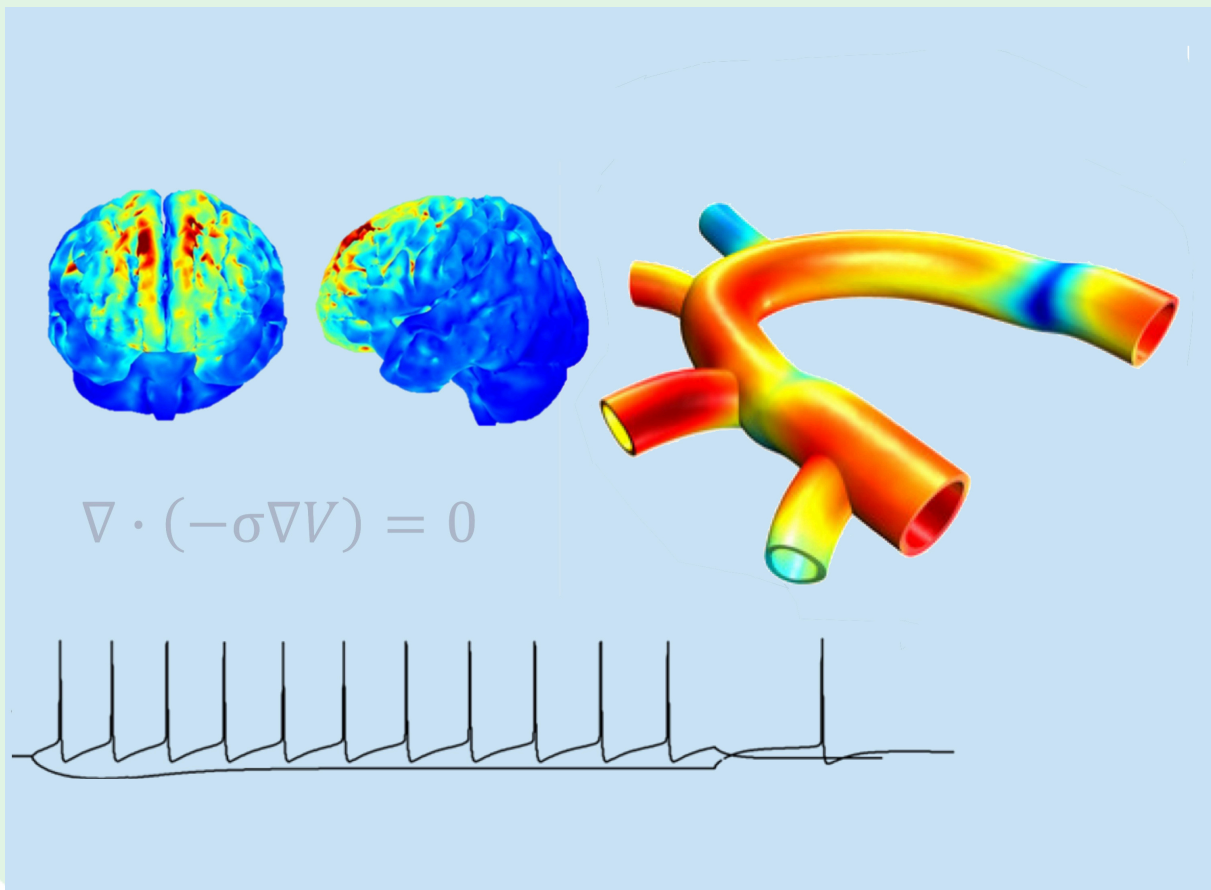


BIOM9711

Modelling Organs, Tissues and Devices

Term 1, 2023



Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Socrates Dokos	s.dokos@unsw.edu.au	Mondays 4-5 pm (online). Appointments can also be made via e-mail.	Room 506 Samuels Building (F25)	9385 9406

School Contact Information

Student Services can be contacted via unsw.to/webforms.

Course Details

Units of Credit 6

Summary of the Course

Computer modelling of complex physiological systems and their interaction with medical devices is becoming increasingly important in modern medical device design. This course provides a practical overview of computational modelling in bioengineering, focusing on a range of applications including electrical stimulation of neural and cardiac tissue, implantable drug delivery, cancer therapy, biomechanics and blood flow. You will be introduced to the basic principles of modelling and simulation of dynamic physical systems using ordinary and partial differential equations, as well as how to implement and solve models using Matlab and COMSOL Multiphysics numerical software.

Course Aims

This course aims to provide a practical overview of computational modelling in bioengineering, focusing on a range of applications of importance for modelling organs, tissues and devices. You will be taught the basic principles of modelling and simulation of continuum dynamic physical systems using ordinary and partial differential equations.

Course Learning Outcomes

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

Learning Outcome	EA Stage 1 Competencies
1. Solve systems of ordinary and partial differential equations using a range of theoretical and computational techniques.	PE1.1, PE1.2
2. Model various biomedical systems using ordinary and partial differential equations.	PE1.2
3. Implement and solve models in Matlab and COMSOL Multiphysics.	PE2.1
4. Identify the basic principles underlying electrical stimulation, drug delivery, heat flow, solid mechanics, fluid mechanics, and their interactions in various body tissues and medical devices.	PE1.1, PE1.3
5. Implement and solve a complex bioengineering model in COMSOL Multiphysics.	PE2.2

Teaching Strategies

This course will be taught via weekly online lectures and computer laboratories. Students will be expected to apply the theory covered in the lectures to the weekly pre-class exercises, team-based learning activities and homework assignments. Assessments and feedback will be regularly provided to the students.

Students learn modelling principles effectively via exposure to a broad range of modelling examples

reinforced through computer-based assignments. Hence, a large proportion of this course is dedicated to team-based learning exercises and homework assignments. In addition, students will gain extensive modelling experience by implementing a full biomedical model of their choice as a major project.

Additional Course Information

Pre-class exercises, group activities and homework assignments

Each week, pre-class exercises will be posted on Moodle to help you prepare for the computer laboratory. You will be required to answer these questions online prior to each week's laboratory class. During the computer laboratory class itself, you will be given an individual test under exam conditions (30 minutes), followed by an opportunity to confer with members of your allotted class group and post a revised answer to the same exercises (another 15 minutes). Your team-based learning mark for that week will consist of the sum of your individual submission and your submission following group discussion. The remainder of the laboratory class will consist of further group submissions and following through with worked problems. This latter class work is not assessable.

Each week, you will also be given a homework assignment (9 assignments in total), each due Tuesday, 12 noon, the following week.

All lectures each week will be pre-recorded: you may watch this lecture at any time of your convenience prior to your scheduled weekly Wednesday laboratory class.

Every week, Monday 4-5 pm (i.e. in the latter half of the scheduled weekly lecture slot), there will be a 1 hour online consultancy session where students can ask questions related to lectures, assignments, or other course content.

Major project

You will be required to implement a bioengineering model of your choice using COMSOL Multiphysics numerical software. Your model must first be approved by the course coordinator (via Stage 0, due Monday, Week 4), and will be subdivided into four stages of submission. The final submission (Stage 3) is due 11:55 pm Monday, Week 11.

Recommended learning approaches

The following provides examples of learning approaches highly recommended for this course.

Private Study

- Watch the online lecture each week.
- Read the pre-lecture reading material assigned each week.
- Complete the weekly pre-class exercises and homework assignments.
- Attend the weekly consultancy session if you have any questions related to the course.
- Implement example Matlab/COMSOL models from the lectures and Moodle modules, and make sure you understand these.
- Watch videos on Moodle and read additional material pertaining to Matlab or COMSOL, to master the use of these.

Laboratories

- Work through the weekly team-based learning activities, both the individual and group-based assessments.
- Follow worked examples.
- Work through set weekly class exercises.
- Ask questions.

Homework Assignments

- Allocate sufficient time to work through the assignment questions and submit them before the due date each week.

Major Project

- Choose a bioengineering model from published literature.
- Reflect on how to implement this model in COMSOL.
- Read about the implementation of this model by others, and ask questions.
- Submit the 4 stages of your project by the due dates.

Assessment

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. Major Project	30%	Monday, Week 11	1, 2, 3, 4, 5
2. Computer based Final Exam	30%	TBA	1, 2, 3, 4, 5
3. Online quizzes	10%	During class	1, 2, 3, 4
4. Assignments	30%	Tuesday, 23:55 the following week	1, 2, 3, 4

Assessment 1: Major Project

Start date: Monday, Week 4

Due date: Monday, Week 11

This assessment consists of a major project submission, in which students are required to implement and solve a biomedical engineering computational model of their choice using COMSOL Multiphysics software. Along with the model itself, students are also required to submit a six-page report in the form of a journal paper. The choice of model must first be approved by the course coordinator (via Stage 0, due Monday, Week 4), and will be subdivided into four stages of submission. The final submission (Stage 3) is due 11:55 pm Monday, Week 11.

This is not a Turnitin assignment

Additional details

You are required to implement a bioengineering model of your choice using COMSOL Multiphysics numerical software. Your model must first be approved by the course coordinator (via Stage 0), and will be subdivided into the following four stages of submission:

Stage 0 (no marks, due 11:55 pm Monday, Week 4): You are required to submit a 100-word major assignment proposal (via Moodle), along with a published research article or text forming the basis of your model design.

Stage 1 (worth 1.5 marks out of 30, due 11:55 pm Monday, Week 6): A one-page summary of five research articles, reviews, or texts relevant to your model. Ideally, these will serve as references in your final submission report. These references can be descriptions of previous computational models in the field, relevant engineering or physiological principles underlying the model, or general research articles outlining the nature of the problem to be investigated by your model.

Stage 2 (worth 1.5 marks out of 30, due 11:55 pm Monday, Week 8): A brief one- or two-page submission outlining the geometrical structure and layout of your model, along with the main model equations and boundary conditions to be solved for. You must include a description of all terms and parameters used in your equations.

Stage 3 (worth 27 marks out of 30, due 11:55 pm Monday, Week 11): The final submission of your

model and report. If necessary, you may modify model details and references from those submitted in stages 0, 1 or 2, as modelling is often an iterative process requiring frequent refinements.

Assessment 2: Computer based Final Exam

Start date: TBA

Due date: TBA

The final exam for this course will be open book and online.

Assessment 3: Online quizzes

Start date: During class

Due date: During class

Each week, pre-class exercises will be posted on Moodle to help you prepare for the tutorial. You will be required to answer these questions online prior to each week's tutorial. During the tutorial class itself, you will be given an individual test under exam conditions (30 minutes), followed by an opportunity to confer with members of your allotted class group and post a revised answer to the same exercises (another 15 minutes). Your team-based learning mark for that week will consist of the sum of your individual submission and your group submission.

Assessment 4: Assignments

Start date: Made available each Tuesday

Due date: Tuesday, 23:55 the following week

This assessment consists of weekly submissions in which students are required to solve theoretical and computational modelling problems. There will be a total of eight such submissions.

Attendance Requirements

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

Course Schedule

[View class timetable](#)

Timetable

Date	Type	Content
Week 1: 13 February - 17 February	Lecture	Introduction to Modelling in Bioengineering
Week 2: 20 February - 24 February	Lecture	Ordinary Differential Equations
Week 3: 27 February - 3 March	Lecture	Partial Differential Equations
Week 4: 6 March - 10 March	Lecture	Finite Element Method I
Week 5: 13 March - 17 March	Lecture	Finite Element Method II
Week 7: 27 March - 31 March	Lecture	Modelling Electrical Stimulation of Tissue
Week 8: 3 April - 7 April	Lecture	Models of Diffusion and Heat Transfer
Week 9: 10 April - 14 April	Lecture	Solid Mechanics
Week 10: 17 April - 21 April	Lecture	Fluid Mechanics

Resources

Recommended Resources

Textbook

- Modelling Organs, Tissues, Cells and Devices using Matlab and COMSOL Multiphysics, by S. Dokos (Springer, 2017). Available for download from the library

Online Tutorials

- Online Matlab tutorials and courses from Mathworks, Inc can be accessed from <https://au.mathworks.com/academia/tah-portal/university-of-new-south-wales-341489.html>
- Online COMSOL Multiphysics tutorials can be accessed from <http://www.comsol.com/products/tutorials/>
- COMSOL also has a large set of example models in its model library, including complete documentation and model files, which can be accessed within the software itself

Course Evaluation and Development

Student feedback has helped to shape and develop this course, including feedback obtained from on-line evaluations as part of UNSW's as part of UNSW's myExperience process. You are highly encouraged to complete such an on-line evaluation toward the end of Session. Feedback and suggestions provided will be important in improving the course for future students. Changes to the course from previous comments received have included more hands-on model examples in lectures and in the laboratories.

Laboratory Workshop Information

Students will attend the same allocated computer laboratory class each week, each class located in Rm 518, Level 5, Samuels Building (F25).

- Class 1: Wednesday 10:00 - 12:00
- Class 2: Wednesday 12:00 - 14:00

Submission of Assessment Tasks

Laboratory reports and major assignments will require a [Non Plagiarism Declaration Cover Sheet](#).

Assignments should be submitted on time. A daily penalty of 5% of the marks available for that assignment will apply for work received after the due date. Any assignment more than 5 days late will not be accepted. The only exemption will be when prior permission for late submission has been granted by the Course coordinator. Extensions will be granted only on medical or compassionate grounds under extreme circumstances.

Academic Honesty and Plagiarism

PLAGIARISM

Beware! An assignment that includes plagiarised material will receive a 0% Fail, and students who plagiarise may fail the course. Students who plagiarise will have their names entered on a plagiarism register and will be liable to disciplinary action, including exclusion from enrolment.

It is expected that all students must at all times submit their own work for assessment. Submitting the work or ideas of someone else without clearly acknowledging the source of borrowed material or ideas is plagiarism.

All assessments which you hand in must have a [Non Plagiarism Declaration Cover Sheet](#). This is for both individual and group work. Attach it to your assignment before submitting it to the Course Coordinator or at the School Office.

Plagiarism is the use of another person's work or ideas as if they were your own. When it is necessary or desirable to use other people's material you should adequately acknowledge whose words or ideas they are and where you found them (giving the complete reference details, including page number(s)). The Learning Centre provides further information on what constitutes Plagiarism at:

<https://student.unsw.edu.au/plagiarism>

Academic Information

COURSE EVALUATION AND DEVELOPMENT

Student feedback has helped to shape and develop this course, including feedback obtained from on-line evaluations as part of UNSW's myExperience process. You are highly encouraged to complete such an on-line evaluation toward the end of Term. Feedback and suggestions provided will be important in improving the course for future students.

DATES TO NOTE

Refer to MyUNSW for Important Dates, available at:
<https://my.unsw.edu.au/student/resources/KeyDates.html>

ACADEMIC ADVICE

For information about:

- Notes on assessments and plagiarism,
- Special Considerations,
- School Student Ethics Officer, and
- BESS

refer to the School website available at
<http://www.engineering.unsw.edu.au/biomedical-engineering/>

Supplementary Examinations:

Supplementary Examinations for Term 1 2023 will be held on (TBC) should you be required to sit one.

This course outline sets out description of classes at the date the Course Outline is published. The nature of classes may change during the Term after the Course Outline is published. Moodle should be consulted for the up to date class descriptions. If there is any inconsistency in the description of activities between the University timetable and the Course Outline (as updated in Moodle), the description in the Course Outline/Moodle applies.

Image Credit

Model images taken from A/Prof Dokos' own research. Aortic graphic is taken from COMSOL's model library at <https://www.comsol.com/model/fluid-structure-interaction-in-a-network-of-blood-vessels-660>

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	