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BIOM9711

Modelling Organs, Tissues and Devices

Term One // 2021

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Socrates Dokos	s.dokos@unsw.edu.au	Appointments via e-mail	Room 506 Samuels Building (F25)	9385 9406

School Contact Information

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

Course Details

Credit Points 6

Summary of the Course

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. Students will be able to solve systems of ordinary and partial differential equations using a range of theoretical and computational techniques.	PE1.2, PE1.1
2. Students will be able to model various biomedical systems using ordinary and partial differential equations.	PE1.2
3. Students will be able to implement and solve models in Matlab and COMSOL Multiphysics.	PE2.1
4. Students will be able to 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.	PE1.3, PE1.1
5. Students will be able to 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 (face-face and fully online classes are available). Students will be expected to apply theory covered in the lectures to the weekly pre-class exercises, team-based learning activities and the 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 team-based learning and computer-based assignments. Hence, a large proportion of this course is dedicated to team-based learning exercises and homework assignments. Feedback provided by laboratory demonstrators is important in teaching correct understanding of practical modelling principles. In addition, students will gain extensive modelling experience by implementing a full biomedical model from the literature 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 lecture. 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 30 minutes). Your team-based learning mark for that week will consist of the averaged marks between 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 Wednesday 11:55 pm the following week.

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 exercices and homework assignments
- 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

Tutorials

- 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 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 Tasks

Assessment task	Weight	Due Date	Student Learning Outcomes Assessed
Major Project	30%	26/04/2021 11:55 PM	2, 3, 4, 5
Computer based Final Exam	30%	Not Applicable	2, 3, 4, 5
Online quizzes	20%	Not Applicable	2, 3, 4, 5
Assignments	20%	Not Applicable	2, 3, 4, 5

Assessment Details

Assessment 1: Major Project

Start date: 15/02/2021 09:00 AM

Details:

This assessment consists of a major project submission, in which students are required to implement and solve a biomedical engineering 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.

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.

Turnitin setting: This is not a Turnitin assignment

Assessment 2: Computer based Final Exam

Start date: Not Applicable

Details:

Final exam, open book. You will be required to implement and solve a given bioengineering model in COMSOL.

Assessment 3: Online quizzes

Start date: Not Applicable

Details:

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 30 minutes). Your team-based learning mark for that week will consist of the averaged marks between your individual submission and your submission following group discussion.

Assessment 4: Assignments

Start date: Not Applicable

Details:

This assessment consists of weekly submissions in which students are required to solve various theoretical and computational modelling problems. There will be a total of nine 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: 15 February - 19 February	Lecture	Introduction to Modelling in Bioengineering
Week 2: 22 February - 26 February	Lecture	Ordinary Differential Equations
Week 3: 1 March - 5 February	Lecture	Partial Differential Equations
Week 4: 8 March - 12 March	Lecture	Finite Element Method I
Week 5: 15 March - 19 March	Lecture	Finite Element Method II
Week 7: 29 March - 2 April	Lecture	Modelling Electrical Stimulation of Tissue
Week 8: 5 April - 9 April	Lecture	Models of Diffusion and Heat Transfer
Week 9: 12 April - 16 April	Lecture	Solid Mechanics
Week 10: 19 April - 23 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**
- A downloadable pdf chapter on solving systems of ordinary differential equations (ODEs) using Matlab, from the text Numerical Computing with Matlab, by Cleve Moler, is at **www.mathworks.com/moler/odes.pdf**
- 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, either the face-face or online class.

- Face-face class: Thursday 12:00 - 14:00, Rm 518, Level 5, Samuels Building (F25)
- Online class: Thursday 16:00 - 18:00 via the Online Collaboration Sessions link located near the top of the Moodle module for the course

Submission of Assessment Tasks

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

Late submissions will be penalised 10% of the mark for each calendar day late. If you foresee a problem in meeting the nominated submission date please contact the Course Convenor to make an appointment to discuss your situation as soon as possible.

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 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 2021 will be held on Monday 24th May – Friday 28th May (inclusive) should you be required to sit one.

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	