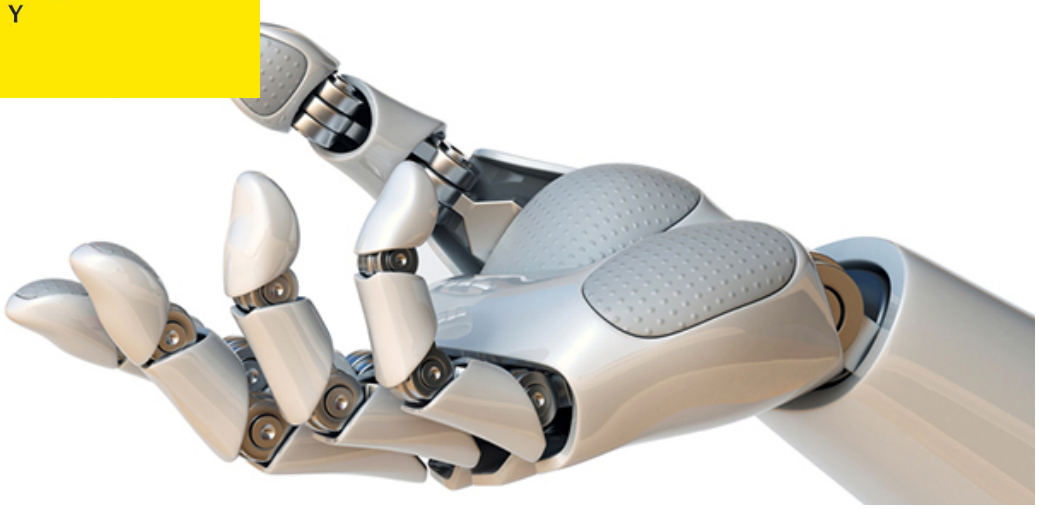

BIOM9660

Bionics and Neuromodulation

Term Two // 2021

Graduate School of Biomedical Engineering // UNSW Engineering

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Mohit Shivdasani	m.shivdasani@unsw.edu.au	Message on Teams or Email to Make Appointment	Room 515A, Level 5, Samuels Building	0401311423

Demonstrators

Name	Email	Availability	Location	Phone
Laurence Boss	l.boss@unsw.edu.au			
Michael Italiano	biomedeng@unsw.edu.au			

School Contact Information

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

Course Details

Credit Points 6

Summary of the Course

A person who was born deaf or lost their hearing later in life can now hear because of a **Cochlear Implant**. A person with Parkinson's disease who lost the ability to control their muscles or someone with epilepsy whose brain suddenly goes into an overdrive state, can regain normal function because of **Deep Brain Stimulation**. A person who has lost sight from a progressive disease can see again because of a **Bionic Eye**. A person with constant pain in their body, so much that their lives are literally controlled by it can lead a normal life because of **Spinal Cord Stimulation**. These are technologies that exist today because of engineers such as yourselves.

Welcome to "Bionics and Neuromodulation". This course will provide you with the appropriate background theory and knowledge of therapeutic bionic devices used to treat a range of disorders such as the ones mentioned above. This course will also provide you with the knowledge of how these devices interact with the human nervous system to induce a therapeutic effect through a process called neuromodulation. By the end of the course you should have a fundamental understanding of the important factors that dictate the success or failure of such devices as well as the important factors surrounding their design. You should also be qualified to advise on the choices available for a given therapeutic application and the advantages and disadvantages of each alternative. Finally, you should also learn how the "biology" i.e. our own bodies interact with these artificial devices and challenges on how to make devices safe and effective. A key element of this course is that you will get to learn first-hand from lecturers who are involved in the research and development of these devices both at UNSW and in the industry sector from two of Australia's leading companies, Cochlear Limited and Saluda Medical. You will also get to hear views from the end users of some of these devices.

This course is for all engineers from various backgrounds and disciplines – as long as you want to design something to help humans. It is natural for engineers from different disciplines to migrate to their 'comfort zone' when approaching the design of a medical implant. For instance, the electrical engineer will tend to concentrate on implant circuitry, the materials engineer is more likely to have an interest in implant packaging or electrode materials, the software engineer will really keep the end users in mind when designing the human machine interface and the chemical engineer will worry about the chemical reactions that occur as a result of electrical stimulation. However, an important objective of the course is to also gain working knowledge of, and confidence to operate in, a broad range of topics within the field of bionics, as well as to highlight the opportunities of working in this field when the 'comfort zones' are broadened. Therefore, you will also experience learning concepts that may be out of your immediate engineering discipline.

Australia has a rich history in bionics and neuromodulation that can be traced back to the world's first attempt at creating a bionic eye in the 1950s, world-leading cardiac pacemaker and defibrillator technologies in the 1960s, to the remarkable cochlear implant in the 1970s that has to date restored the sense of hearing to over a million people. In this course we will explore some of these devices in clinical application and research. Key factors that determine the success or failure of devices will be studied, and fundamental theory and background knowledge will be conveyed through a series of lectures. Key elements common to all devices such as wireless power delivery, software coding for devices and electrochemical reactions from stimulation will be experienced through hands-on laboratory exercises. You will also enjoy learning about the intricacies of sound processing for cochlear implants through an engaging assignment. But most importantly, you will gauge an immense appreciation of how multiple disciplines speaking "different technical languages" can come together to make a difference and

transform people's lives. Our hope is that this course will help you be part of the next generation of biomedical engineers and who will perpetuate Australia's leading role in the field of bionics.

Course Aims

The aims of this course are to:

- introduce students to the fundamentals of bionic devices, their relation to understanding therapeutic sensory and functional neural stimulation as well as their ability to modulate the activity of neurons
- understand the principles which govern the application of electrical neural stimulation and the design of instruments to be used for this purpose
- understand various applications of therapeutic electrical neural stimulation including the underlying biological process that dictate the success or failure of such devices

Course Learning Outcomes

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

Learning Outcome	EA Stage 1 Competencies
1. Explain the scope of various implantable and non-implantable bionic devices in terms of their applications in medicine	PE1.1, PE1.2, PE1.3, PE1.4, PE1.5
2. Explain the fundamental factors that drive the safety and efficacy of neuromodulation using electrical stimulation	PE1.1, PE1.2, PE1.3, PE1.4, PE1.5
3. Identify the complexities and specific challenges (surgical, clinical, electrical, mechanical, chemical, materials and software) related to life-long bionic device design	PE1.1, PE1.2, PE1.3, PE1.4, PE1.5
4. Review aspects of the literature surrounding bionic devices and assess the knowledge gained to formulate hypotheses, plan and carry out experiments to address these hypotheses	PE2.1, PE2.2
5. Solve a range of practical problems related to bionic devices in a team	PE2.1, PE2.2, PE3.6
6. Express findings from the bionics literature and one's own work using oral and written methods	PE3.2, PE3.4, PE3.6

Teaching Strategies

The course agenda for 2021 will consist of face-to-face lectures and laboratory work. Each week there will be a lecture of up to three hours duration, and throughout the term the principles of the lecture will be reinforced through 2-hour laboratory sessions. Students will work on problems both individually and in groups. Students enrolled in the course will be given access to a course module using UNSW Moodle where course material will be placed to comply with University policies. A Microsoft Teams site will also be created to facilitate communication and discussion. The primary communication/contact method shall be via MS Teams and each student's university e-mail account. It is up to the student to ensure that their university e-mail account is maintained and checked regularly or forwarded to an e-mail account that is checked regularly. Assessments and feedback on work will be regularly provided to the students.

Additional Course Information

This course involves a total of 5 contact hours per week. For each hour of contact it is expected that you will put in at least 1.5-2 hours of private study.

Assessment

It is prudent to describe the philosophy of assessment that will be applied.

First, deadlines are deadlines, not guidelines or suggestions so you are required to hand-in all assessments on-time if they expect to obtain credit for them. Penalties will be applicable for late submissions. There are cases where legitimate and serious circumstances preclude one from accomplishing something by a particular time, but these are rare and obvious, and can be dealt with on a case-by-case basis provided formal special consideration requests are applied for **in sufficient advance** of the deadline.

Second, keeping up in this course is crucial. There is a great deal of material to cover, and a limited time in which to cover it. For this reason, assessment events will be frequent and so will require that you stay on top of course material at all times throughout the term. If a lecture is missed, ensure that notes are obtained by other means. Slides for all lectures will be made available and all lectures will be recorded. Sharing of notes and open discussion of course material is strongly encouraged, but unless otherwise stated, all work submitted for assessment must be your own, unique and original work. Failure to comply can result in a zero mark for the assessment task and subject to the university's misconduct policies.

Assessment Tasks

Assessment task	Weight	Due Date	Student Learning Outcomes Assessed
Laboratories - Participation and Reports	45%		1, 2, 3, 4, 5, 6
Quizzes	20%		1, 2, 3, 6
Major Assignment	25%		4, 5, 6
Reading Game	10%		5

Assessment Details

Assessment 1: Laboratories - Participation and Reports

Details:

A series of laboratory sessions will be conducted in weeks 1-5 and 7-9 to perform practical experiments. These experiments will complement and add to the concepts introduced in the lectures. Each lab topic will be covered across two consecutive weeks. You will work in groups during the labs. Attendance and participation in the laboratory sessions will be marked. There will be three lab reports that you will need to **prepare individually**, each worth 15% and due one week after the end of each lab topic.

Assessment 2: Quizzes

Details:

A total of four quizzes will be conducted during the term in selected weeks (see course timetable). These will be administered within Moodle promptly at the start of the lecture period and will be of 15-20 minutes

duration. Quizzes must be attempted within the relevant lecture window, unless exceptional circumstances prevent this, which will be dealt with on a case-by-case basis. Students are expected to prepare for each quiz by studying the lecture and laboratory materials from the previous weeks. Short answer or multiple-choice questions will be the norm, and the aim will be to assess the student's understanding of the material as the course progresses (breadth as well as depth). Be advised that once a concept is introduced to the course, it may appear on any assessment event from that point onward. For instance, if a concept is introduced during week 1, a question on that concept could be on a quiz in week 7 (or any other week after week 1).

Assessment 3: Major Assignment

Details:

A comprehensive project (due in parts in weeks 8, 10 and 11) on the topic relating to sound processing in cochlear implants will form an integral requirement of the course. The assessments will include both individual (worth 10%) and group work (worth 15%). The details of this major assignment will be provided in the first few weeks of the course.

Assessment 4: Reading Game

Details:

One of the most effective ways to learn is by asking questions, particularly good questions to your peers and answering questions that your peers have asked. To facilitate learning of each other, we will play a competitive Q&A game throughout the term – all about asking good questions on which you will be assessed on. Details will be provided in the lecture during week 1.

Attendance Requirements

To gain marks for laboratory reports for a particular topic, students must have attended the lab sessions related to the topic.

Course Schedule

View class timetable

Timetable

Date	Type	Content
O Week: 25 May - 28 May	Online Activity	Read course outline thoroughly and start imagining "Bionics"!
Week 1: 31 May - 4 June	Lecture	Introduction to BIOM9660 and Medical Bionics (Dr Mohit Shivdasani)
	Group Activity	Laboratory - Radio Frequency Links Part 1
Week 2: 7 June - 11 June	Lecture	Neurons and Neural Modelling (Dr Tianruo Guo, UNSW GSBmE) Fundamentals of Electrical Stimulation (Dr Mohit Shivdasani)
	Group Activity	Laboratory - Radio Frequency Links Part 2
	Assessment	Quiz 1 (At start of lecture)
Week 3: 14 June - 18 June	Lecture	Systems Engineering (Ms Emma Connell, Systems Engineer, Cochlear Ltd) Principles of Hermeticity (Dr Mohit Shivdasani)
	Group Activity	Laboratory - Recording Electromyography Activity Part 1
	Assessment	Radio Frequency Coils Lab Report Due
Week 4: 21 June - 25 June	Lecture	Principles of Charge Injection, Electrodes and Electrochemistry (Prof Paul Carter, Principal Scientist, Cochlear Ltd)
	Group Activity	Laboratory - Recording Electromyography Activity Part 2
	Assessment	Quiz 2 (At start of lecture)
Week 5: 28 June - 2 July	Lecture	Sound Processing in Cochlear Implants (Dr Brett Swason, Principal Scientist, Cochlear Ltd) Cochlear Implants: A personal perspective (Dr Greg Watkins, University of Sydney)
	Group Activity	Laboratory - Sound Processing Part 1
	Assessment	EMG Activity Lab Report Due
Week 6: 5 July - 9 July	Fieldwork	Field Trip to Cochlear Ltd (To Be Confirmed)
Week 7: 12 July - 16 July	Lecture	Deep Brain Stimulation for Movement Disorders (Dr Mohit Shivdasani)
	Group Activity	Laboratory - Sound Processing Part 2

	Online Activity	Watch Pre-recorded Lecture on Motor Prostheses and Bionic Touch (A/Prof Ingvars Birznieks, NeuRA)
	Assessment	Quiz 3 (At start of lecture)
Week 8: 19 July - 23 July	Lecture	Motor Prostheses and Bionic Touch Live Discussion (A/Prof Ingvars Birznieks, NeuRA)
	Group Activity	Laboratory - Stimulating Electrodes Part 1
	Assessment	Matlab Code for Major Assignment Due
Week 9: 26 July - 30 July	Lecture	Visual Prostheses (Dr Mohit Shivdasani)
	Group Activity	Laboratory - Stimulating Electrodes Part 2
Week 10: 2 August - 6 August	Lecture	Spinal Cord Stimulation for Chronic Pain (Dr Dean Karantonis, Saluda Medical)
	Assessment	Major Assignment Group Presentations Viewed and Assessed in Laboratory Time
	Assessment	Stimulating Electrodes Lab Report Due
	Assessment	Quiz 4 (In week 11 lecture time)
	Assessment	Major Assignment Group Report Due (At end of week 11)

Resources

Recommended Resources

Highly Recommended Textbooks:

1) Implantable Neural Prostheses 1 Devices and Applications; Zhou, David; 2009

2) Implantable Neural Prostheses 2 Techniques and Engineering Approaches; Zhou, David; 2010

3) Neurobionics: The Biomedical Engineering of Neural Prostheses; Shepherd, Robert; 2016

4) Neuroprosthetics: Theory And Practice; Kipke, Daryl R; 2017

Course Evaluation and Development

Feedback throughout the course is encouraged and highly welcome. All feedback will be taken seriously. In the past, student feedback has helped improve the learning experience significantly. Many changes to the course have been made since I started teaching this course in 2018, particularly in relation to respecting student workloads and other commitments. In 2020, a decision was made to eliminate a final exam as an assessment as my strong belief is that this does not contribute much to student learning.

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 2 2021 will be held on Monday 6th September – Friday 10th September (inclusive) should you be required to sit one.

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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	✓