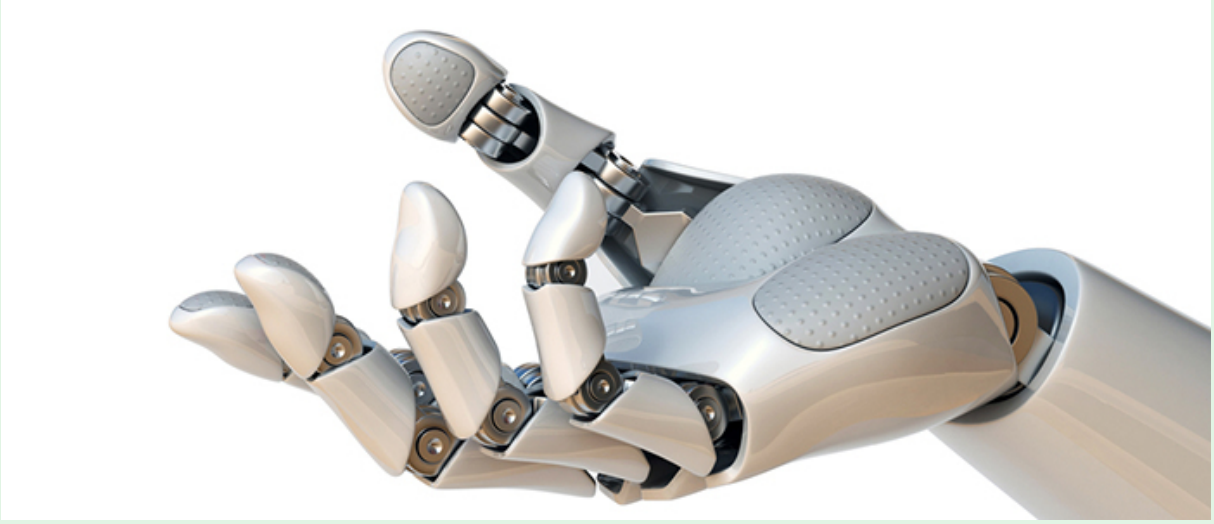
BIOM9660

Bionics and Neuromodulation

Term 2, 2023



Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Mohit Shivdasani	m.shivdasani@unsw.edu.au	By appointment	Room 515A, Level 5, Gordon and Jacqueline Samuels Building	0401311423

Demonstrators

Name	Email	Availability	Location	Phone
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School Contact Information

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

Course Details

Units of Credit 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.

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

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.

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 will consist of a series of in-person 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. In addition, an MS Teams sharepoint site may be created for the primary purposes of communication during the course. The primary contact method shall be via MS Teams/Moodle 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.

The primary rationale for in-person lectures is the various important discussions that are conducted in-class which reinforce deep learning. Another rationale is the significant number of lectures delivered by industry professionals giving students an up to date "real-world" understanding of what it means to have a bionic device on the market. The rationale for in-person labs are so that students get an opportunity to solve practical problems, conduct experiments, analyse data, and therefore reinforce concepts learnt in lectures. This course cannot be undertaken remotely due to the number of practical activities undertaken.

Assessment

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. Sound Processing Coding Assignment	10%	Not Applicable	4, 5, 6
2. Progressive Learning Quizzes and Reading Game	35%	Week 2, Week 3, Week 4, Week 5, Week 7, Week 8, Week 9, Week 10	1, 2, 3, 5, 6
3. Group presentation and evaluation	15%	Not Applicable	4, 5, 6
4. Laboratory Participation and Reports	40%	Not Applicable	1, 2, 3, 4, 5, 6

Assessment 1: Sound Processing Coding Assignment

Students will need to write code in Matlab relating to sound processing in cochlear implants. The details of this coding assignment will be provided in the first week of the course.

Assessment 2: Progressive Learning Quizzes and Reading Game

Start date: 06/06/2023 11:30 AM
Due date: Week 2, Week 3, Week 4, Week 5, Week 7, Week 8, Week 9, Week 10

Progressive Quizzes: Quizzes will be conducted during the term in every week from week 2 right up to week 10 (except week 6). These will be administered within Moodle promptly at the end of the lecture period. Quizzes must be attempted individually and as a group 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 "rapid fire" and calculation 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).

Reading Game: 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 and from each other, we will also 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.

Assessment 3: Group presentation and evaluation (Group)

A group presentation in the form of a video or live presentation that describes a topic in Bionics. This will be marked by both the course co-ordinator (worth 5%) and by your peers (5%). In addition, students will complete a group evaluation at the end of the term. 2.5% will be weighted for completing the evaluation of your team members as an individual, and 2.5% will be based on the evaluation students receive from

other team members. Presentations and evaluations will occur in the lab sessions in weeks 9 and 10.

Assessment 4: Laboratory Participation and Reports

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 three consecutive weeks. You will work in groups during the labs. Attendance and participation in the laboratory sessions will be marked. There will be two lab reports that you will need to prepare individually, one worth 15% and the other worth 25%. Due dates for the lab reports will be end of week 6 and end of week 11.

Attendance Requirements

Both, lectures and labs are expected to be attended in person unless special circumstances apply.

Course Schedule

View class timetable

Timetable

Date	Type	Content
O-Week: 22 May - 26 May	Homework	Read course outline, attend online MATLAB Ramp course and submit certificate
Week 1: 29 May - 2 June	Lecture	Introduction to BIOM9660 and Medical Bionics (A/Prof Mohit Shivdasani)
	Laboratory	Introduction to Oscilloscopes and Matlab
Week 2: 5 June - 9 June	Lecture	Fundamentals of Electrical Stimulation and Hermeticity (A/Prof Mohit Shivdasani)
	Laboratory	Recording EMG activity - Part 1
	Assessment	In class individual and group quiz
	Assessment	Progressive Learning Quizzes and Reading Game
Week 3: 12 June - 16 June	Lecture	Sound Processing Strategies for Cochlear Implants (Dr Brett Swanson and Dr Greg Watkins, Cochlear Ltd)
	Laboratory	Recording EMG activity - Part 2
	Assessment	In class individual and group quiz
	Assessment	Progressive Learning Quizzes and Reading Game
Week 4: 19 June - 23 June	Lecture	Systems Engineering (Ms Sam Connolly, Cochlear Ltd) and Modelling in Bionics (Dr Tianruo Guo, UNSW)
	Laboratory	Recording EMG activity - Part 3
	Assessment	In class individual and group quiz
	Assessment	Progressive Learning Quizzes and Reading Game
Week 5: 26 June - 30 June	Lecture	Mechanisms of Charge Injection, Electrodes and Electrochemistry (Prof Paul Carter, Cochlear Ltd)

	Laboratory	Stimulating Electrodes - Part 1
	Assessment	In class individual and group quiz
	Assessment	Progressive Learning Quizzes and Reading Game
Week 6: 3 July - 7 July	Fieldwork	Possible field trip to a bionics company
	Assessment	EMG Lab Report Due Sunday
Week 7: 10 July - 14 July	Lecture	Deep Brain Stimulation for Movement Disorders (A/Prof Mohit Shivdasani)
	Laboratory	Stimulating Electrodes - Part 2
	Assessment	In class individual and group quiz
	Assessment	Progressive Learning Quizzes and Reading Game
Week 8: 17 July - 21 July	Lecture	Motor Prostheses and Bionic Touch (A/Prof Ingvars Birznieks, NeuRA)
	Laboratory	Stimulating Electrodes - Part 3
	Assessment	In class individual and group quiz
	Assessment	Progressive Learning Quizzes and Reading Game
Week 9: 24 July - 28 July	Lecture	Spinal Cord Stimulation for Chronic Pain (Mr Milan Obradovic, Saluda Medical)
	Assessment	Group Presentations
	Assessment	In class individual and group quiz
	Assessment	Progressive Learning Quizzes and Reading Game
Week 10: 31 July - 4 August	Lecture	Bionic Vision Restoration (A/Prof Mohit Shivdasani)
	Assessment	In class individual and group quiz
	Assessment	Final Matlab Code Due Sunday
	Assessment	Progressive Learning Quizzes and Reading Game
Stuvac: 7 August - 11 August	Assessment	Electrodes Lab Report Due Sunday

Resources

Recommended Resources

Highly Recommended Textbooks:

1) Implantable Neural Prostheses 1 Devices and Applications; Zhou, David; 2009
https://www.bookshop.unsw.edu.au/details.cgi?ITEMNO=9781493950836
2) Implantable Neural Prostheses 2 Techniques and Engineering Approaches; Zhou, David; 2010
https://www.bookshop.unsw.edu.au/details.cgi?ITEMNO=9781461424673
3) Neurobionics: The Biomedical Engineering of Neural Prostheses; Shepherd, Robert; 2016
https://www.bookshop.unsw.edu.au/details.cgi?ITEMNO=9781118814871
4) Neuroprosthetics: Theory And Practice; Kipke, Daryl R; 2017
https://www.bookshop.unsw.edu.au/details.cgi?ITEMNO=9789813207141

Highly Recommended Journal Papers:

1) Merrill et al. (2005) Electrical stimulation of excitable tissue: design of efficacious and safe protocols. Journal of Neuroscience Methods 141:171-198.
2) Cogan (2008) Neural stimulation and recording electrodes. Annual Reviews in Biomedical Engineering.

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?il, 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 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.

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	✓