UNSW Course Outline

BIOM9621 Biological Signal Analysis - 2024

Published on the 25 Aug 2024

General Course Information

Course Code : BIOM9621
Year : 2024
Term : Term 3
Teaching Period : T3
Is a multi-term course? : No
Faculty : Faculty of Engineering
Academic Unit : Graduate School of Biomedical Engineering
Delivery Mode : In Person
Delivery Format : Standard
Delivery Location : Kensington
Campus : Sydney
Study Level : Undergraduate, Postgraduate
Units of Credit : 6

Useful Links

Handbook Class Timetable

Course Details & Outcomes

Course Description

Biological signal analysis focuses on extracting valuable information from signals generated by biological systems. As a biomedical engineer you will be applying your expertise in signal analysis to develop algorithms that power medical devices. This course will take you through the

fundamentals of signal analysis including linear systems, spectral analysis, filter design and feedback control that will provide you with a solid foundation for development of medical devices. You will learn how to creatively apply the signal analysis toolbox to solve challenging biomedical design problems.

Course Aims

This course is an important element of the biomedical engineering program as it equips students with the necessary skills to extract, analyse, and filter biological signals. Additionally, these principles are useful for the design and control of medical devices.

Therefore the course aims are to:

1. To gain a practical knowledge of how to record biological signals digitally without artefact
2. To analyse the frequency content of these signals and design digital filters to remove noise
3. To identify a biological system model by analysing system input and output signals
4. To have a working knowledge of the numerical tools required for signal analysis
5. Enhance a biomedical engineering student's design skills

Relationship to Other Courses

BIOM9621 focuses on signal analysis theory that underpins the acquisition and sampling of continuous signals, associated artefacts, spectral analysis and filter design. BIOM9621 serves as a foundational course for BIOM9620 and BIOM9650, which focus on neural interfaces and biosensors, respectively.

Course Learning Outcomes

Course Learning Outcomes
CLO1 : Explain the application of linear systems analysis to biological systems
CLO2 : Acquire, simulate and display signals using Matlab and Simulink
CLO3 : Analyse the acquired data with respect to frequency content using Matlab
CLO4 : Avoid and minimise artefacts that can arise during data acquisition
CLO5 : Collaborate with others to develop a medical device controller

Course Learning Outcomes	Assessment Item
CLO1 : Explain the application of linear systems analysis to biological systems	
CLO2 : Acquire, simulate and display signals using Matlab and Simulink	
CLO3 : Analyse the acquired data with respect to frequency content using Matlab	
CLO4 : Avoid and minimise artefacts that can arise during data acquisition	
CLO5 : Collaborate with others to develop a medical device controller	

Learning and Teaching Technologies

Moodle - Learning Management System | Microsoft Teams | Echo 360

Additional Course Information

Biological systems and electrical circuits can be modelled as linear time-invariant (LTI) systems, mathematically represented by linear ordinary differential equations in the time domain. The response of an LTI system to an impulse or sinusoidal signal is analysed using Laplace and Fourier Transforms. The response of an LTI system to an arbitrary signal is modelled using convolution.

Digital sampling artifacts, such as aliasing, spectral leakage, and signal replication, are explained by convolution with special functions like the Shah function (an infinite sequence of unit impulses) and the rectangular function. Digital signals or discretely sampled biological signals are analysed using the Z-transform, which underpins digital filters' design and frequency response.

These concepts are taught through a combination of lectures, tutorials, interactive online

activities, and group work using a USB signal generator/oscilloscope. The course extensively uses the Matlab signal analysis toolbox, a powerful software tool, to represent the transfer function of LTI systems and to assist in the design of digital filters. This hands-on experience with industry-standard tools will prepare you for real-world applications in signal processing.

Assessments

Assessment Structure

Assessment Item	Weight	Relevant Dates
Major topics online quizzes Assessment Format: Individual	44%	Start Date: Not Applicable Due Date: Not Applicable
Major assignment Assessment Format: Individual	20%	Start Date: Not Applicable Due Date: Not Applicable
Lab reports Assessment Format: Individual	20%	Start Date: Not Applicable Due Date: Not Applicable
Group project Assessment Format: Group	16%	Start Date: Not Applicable Due Date: Not Applicable

Assessment Details

Major topics online quizzes

Assessment Overview

There will be Introductory Maths revision and Matlab skills online quizzes. There will be 5 online quizzes that will assess signal analysis theory covering 1) Linear time-invariant systems 1 2) Linear time-invariant systems 2 3) Fourier Transform 4) Digital Sampling 5) Z-transform and Digital Filtering. They will be based upon online learning activities for each of these major topics.

Assignment submission Turnitin type

Not Applicable

Generative AI Permission Level

No Assistance

This assessment is designed for you to complete without the use of any generative AI. You are not permitted to use any generative AI tools, software or service to search for or generate information or answers.
For more information on Generative AI and permitted use please see here.

Major assignment

Assessment Overview

Major assignment

Assignment submission Turnitin type

Not Applicable

Generative AI Permission Level

Simple Editing Assistance

In completing this assessment, you are permitted to use standard editing and referencing functions in the software you use to complete your assessment. These functions are described below. You must not use any functions that generate or paraphrase passages of text or other media, whether based on your own work or not.
If your Convenor has concerns that your submission contains passages of AI-generated text or media, you may be asked to account for your work. If you are unable to satisfactorily demonstrate your understanding of your submission you may be referred to UNSW Conduct & Integrity Office for investigation for academic misconduct and possible penalties.
For more information on Generative AI and permitted use please see here.

Lab reports

Assessment Overview

There will be two lab reports (8 % each) based on analogue and digital signal processing labs.

Assignment submission Turnitin type

Not Applicable

Generative AI Permission Level

Simple Editing Assistance

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Group project

Assessment Overview

The group project will apply biological signal analysis to a clinical problem. The assessment includes group reports, presentations and individual analysis.

Detailed Assessment Description

The group project's objective is to develop and evaluate a ventilator controller to assist COVID pneumonia patients requiring ventilation. To simulate the impact of deteriorating lung function on parameters like blood pressure and oxygen saturation, the Simulink package Pneuma will be employed. Students will form groups of four during the sixth week. The ventilator controller will then be subjected to simulation tests on ten patients exhibiting varying degrees of lung function loss. In week 10, each group will present their project to the class, and individual written reports will be submitted.
The assessment of the written reports will be based on:
1. The quality of the literature review.
2. The application of signal analysis theory to address the problem.
3. A comprehensive description of the controller's design and testing.
4. Verification of the controller's performance on the ten simulated patients.
5. A reflection on the level of collaboration within the group.

Assignment submission Turnitin type

Not Applicable

Generative AI Permission Level

Simple Editing Assistance

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General Assessment Information

Grading Basis

Standard

Course Schedule

Teaching Week/Module	Activity Type	Content
Week 1 : 9 September - 15 September	Blended	Introduction to the course including maths revision. Introduction to the Analog 2 Discovery USB signal generator and oscilloscope. Simulation of the arterial pulse.
Week 2 : 16 September - 22 September	Blended	Linear time-invariant systems 1 including special functions, criteria for linearity and time invariance. Modelling linear time-invariant systems using linear ordinary differential equations. Problem-solving (group work). Frequency response of a low pass filter.
Week 3 : 23 September - 29 September	Blended	Linear time-invariant system II. Topics covered include Laplace transform, Inverse Laplace transform, convolution, impulse response, transfer function, stability of LTI systems, solving linear ODEs using the Laplace transform. Plotting the transfer function for the low pass filter. Simulating a spring-damper model using Simulink. Problem-solving (group work).
	Assessment	LTI 1 online quiz.
Week 4 : 30 September - 6 October	Blended	Fourier transform including the convolution theorem, replication, rescaling and the Fourier series. Tutorial Problem solving (group work)
	Assessment	Fourier Transform Laboratory and lab report.
	Assessment	LTI 2 online quiz
Week 5 : 7 October - 13 October	Blended	Digital sampling includes defining the bandwidth and Nyquist frequency of the sampled signal. Understanding aliasing artefacts using the replication theorem. Spectral resolution and the fast Fourier transform. Discrete-time Fourier transform.
	Assessment	Digital sampling laboratory and lab report.
	Assessment	Fourier transform online quiz.
Week 6 : 14 October - 20 October	Group Activity	Design of a ventilator controller including Pneuma (Simulink) for physiological modelling of the respiratory and cardiovascular systems, formation of groups (4 per team), and allocation of roles and responsibilities.
	Assessment	Report for lab 1 (Fourier transform).
Week 7 : 21 October - 27 October	Blended	Z-transform and introduction to digital filtering including digital filters, digital filter stability and frequency response. Digital filter design using the Matlab Signal Analysis Toolbox.
	Assessment	Digital sampling online quiz
	Assessment	Report for lab 2 (digital sampling)
Week 8 : 28 October - 3 November	Blended	PID control for linear systems. Relating PID controller parameters to the step response characteristics of the controlled system and tuning methods. Use of Matlab for system identification and filter design.
Week 9 : 4 November - 10 November	Blended	Discrete Fourier transform and power spectrum estimation. System identification
Week 10 : 11 November - 17 November	Assessment	Ventilator controller design group presentations.
	Assessment	Z-transform and digital filtering online quiz
	Assessment	Major assignment

Attendance Requirements

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

General Schedule Information

The class will be held in K-E15-1043 - Quadrangle 1043 | Learning Environments - UNSW Sydney on Thursdays from 2-5 pm. The class will include a short lecture, tutorial, and group work. Online quizzes will be held on Wednesdays from 12-1 pm on weeks 3, 4, 5, 7 and 10.

Course Resources

Prescribed Resources

All material will be provided via Moodle with ECHO recording of blended learning Tutorial/Lecture and lab practicals.

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 Course and Teaching Evaluation and Improvement (MyExperience) process.

Staff Details

Position	Name	Email	Location	Phone	Availability	Equitable Learning Services Contact	Primary Contact
Convenor	Robert Nordon		Room 508	0432337006	By appointment	Yes	Yes
Lecturer	Reza Argha				During class time or by teams.	No	No

Other Useful Information

Academic Information

I. 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, or within 3 working days of, submitting an assessment or sitting an exam.

Please note that UNSW has a Fit to Sit rule, which means that if you sit an exam, 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, please see the information on UNSW's Special Consideration page.

II. Administrative matters and links

All students are expected to read and be familiar with UNSW guidelines and polices. In particular, students should be familiar with the following:

- Attendance
- UNSW Email Address
- Special Consideration
- Exams
- Approved Calculators
- Academic Honesty and Plagiarism
- Equitable Learning Services

III. Equity and diversity

Those students who have a disability that requires some adjustment in their teaching or learning environment are encouraged to discuss their study needs with the course convener prior to, or at the commencement of, their course, or with the Equity Officer (Disability) in the Equitable Learning Services. Issues to be discussed may include access to materials, signers or note-takers, the provision of services and additional exam and assessment arrangements. Early notification is essential to enable any necessary adjustments to be made.

IV. Professional Outcomes and Program Design

Students are able to review the relevant professional outcomes and program designs for their streams by going to the following link: https://www.unsw.edu.au/engineering/student-life/student-resources/program-design.

Note: This course outline sets out the 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 or your primary learning management system (LMS) 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/Moodle/LMS, the description in the Course Outline/Moodle/LMS applies.

Academic Honesty and Plagarism

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.

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 or contract cheating) even suspension from the university. The Student Misconduct Procedures are available here:

www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf

Submission of Assessment Tasks

Work submitted late without an approved extension by the course coordinator or delegated authority is subject to a late penalty of five percent (5%) 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. This is for all assessments where a penalty applies.

Work submitted after five days (120 hours) will not be 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 will be clearly indicated in the course outline, and such assessments will receive a mark of zero if not completed by the specified date. Examples include:

- Weekly online tests or laboratory work worth a small proportion of the subject mark;
- Exams, peer feedback and team evaluation surveys;
- Online quizzes where answers are released to students on completion;
- Professional assessment tasks, where the intention is to create an authentic assessment that has an absolute submission date; and,
- Pass/Fail assessment tasks.

Faculty-specific Information

Engineering Student Support Services – The Nucleus - enrolment, progression checks, clash requests, course issues or program-related queries

Engineering Industrial Training – Industrial training questions

UNSW Study Abroad – study abroad student enquiries (for inbound students)

UNSW Exchange – student exchange enquiries (for inbound students)

UNSW Future Students – potential student enquiries e.g. admissions, fees, programs, credit transfer

Phone

(+61 2) 9385 8500 – Nucleus Student Hub

(+61 2) 9385 7661 – Engineering Industrial Training

(+61 2) 9385 3179 – UNSW Study Abroad and UNSW Exchange (for inbound students)

School Contact Information

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