School of Engineering

MENG3451: Medical Imaging and Signal Processing

Callaghan
Semester 2 - 2023

COURSE OUTLINE

OVERVIEW

Course Description

An import aspect in medical engineering is to understand and interpret the signals and images captured by medical devices. This course introduces students to the field of medical imaging and signal processing. An introduction to the theoretical framework, experimental techniques, and analysis procedures available for the quantitative analysis of physiological systems and signals is provided. The amplitude and frequency structure of signals, filtering, sampling, correlation functions, time and frequency-domain descriptions of systems are discussed, in particular, considering multidimensional signals. Signal acquisition and analog-to-digital conversion will also be discussed. It details the principles underlying common medical imaging technologies and discusses their clinical applications. Focus here is on image formation and processing covers the main signal and image processing techniques used. Imaging modalities covered include X-ray, positron emission tomography, magnetic resonance, optical and ultrasound. By the end of the course students will be able to analyse medical signals and understand the operation of equipment used to acquire these signals.

Assumed Knowledge

ELEC2430, PHYS1220, MATH1120

Contact Hours

Callaghan
Laboratory
Face to Face On Campus
2 hour(s) per Week for Full Term

Lecture
Face to Face On Campus
3 hour(s) per Week for Full Term

Tutorial
Face to Face On Campus
1 hour(s) per Week for Full Term

Unit Weighting

10

Workload

Students are required to spend on average 120-140 hours of effort (contact and non-contact) including assessments per 10 unit course.

CONTACTS

Course Coordinator

Callaghan
Dr Sajad Ghatrehsamani
Sajad.Ghatrehsamani@newcastle.edu.au
(02) 4921 5289
Consultation: Tuesday 3-5 pm in room EAG31 or by appointment

Teaching Staff

Other teaching staff will be advised on the course Canvas site.

School Office

School of Engineering
EAG03
EA Building
Callaghan
+61 2 4921 5798
9.00am-1.00pm and 2.00pm-5.00pm (Monday to Friday)

SYLLABUS

Course Content

- Amplitude and frequency structure of signals, filtering, sampling, correlation functions, time and frequency-domain descriptions of systems for single- and multi-dimensional signals (e.g. ECG, EMG and EEG)
- X-ray imaging devices: principles, clinical applications, image formation and processing
- Positron emission tomography (PET): principles, clinical applications, image formation and processing
- Magnetic resonance imaging (MRI) devices: principles, clinical applications, image formation and processing
- Optical imaging devices: principles, clinical applications, image formation and processing
- Ultrasound imaging devices: principles, clinical applications, image formation and processing

Course Learning Outcomes

On successful completion of this course, students will be able to:

1. Apply mathematical methods of signal and image processing to acquired medical signals and images.
2. Analyse multidimensional time and frequency domain signals.
3. Apply the principles underlying the operation of medical imaging devices.
4. Analyse the strengths and weaknesses of medical imaging and sensing devices and how these impact upon their common clinical applications.
5. Generate mathematical models by applying their understanding of how medical images are constructed and processed in hardware.

Course Materials

Recommended Reading:

- Bushberg, J. T., Seiberg, J. A., Edwin M. Leidholdt, J., & Boone, J. M. (2020). *The Essential Physics of Medical Imaging*. Wolters Kluwer Health.
- Smith, N. B., & Webb, A. (2010). *Introduction to medical imaging: physics, engineering and clinical applications*. Cambridge university press.
- Flower, M. A. (Ed.). (2012). *Webb's physics of medical imaging*. CRC press.
- Suetens, P. (2017). *Fundamentals of medical imaging*. Cambridge university press.

ASSESSMENTS

This course has 4 assessments. Each assessment is described in more detail in the sections below.

	Assessment Name	Due Date	Involvement	Weighting	Learning Outcomes
1	Laboratory Exercises	Lab 1 - Week 3, Lab 2 - Week 6.	Individual	10%	1, 2, 3, 5
2	Presentation	Week 13. Schedules for the individual presentations will be made available in Canvas.	Individual	30%	3, 4
3	Project	Progressive assessments, Week 4, Week 9 and Week 12	Individual	40%	1, 2, 3, 4, 5
4	Formal Examination	Formal examination period	Individual	20%	1, 2, 5

Late Submissions The mark for an assessment item submitted after the designated time on the due date, without an approved extension of time, will be reduced by 10% of the possible maximum mark for that assessment item for each day or part day that the assessment item is late. Note: this applies equally to week and weekend days.

Assessment 1 - Laboratory Exercises

Assessment Type Tutorial / Laboratory Exercises
Purpose The purpose of the lab exercises is to develop problem based learning skills; develop team work skills and the ability to record data; learn to analyse a problem and synthesise a solution; present results in a clear, well presented and articulate manner.
Description There are 2 lab exercises that will enhance and evaluate the students knowledge on the material presented in lectures and tutorials. Two brief lab reports are required, one for each lab exercise. Demonstration is required at the submission of each report. Each lab will have a weighting of 5%.
Weighting 10%
Length 2 hours
Due Date Lab 1 - Week 3, Lab 2 - Week 6.
Submission Method Online
Source code submission is via Canvas. Students are also required to demonstrate and defend their solution in the lab.
Assessment Criteria Successful understanding and demonstration of signal processing data from several medical imaging modalities. Detailed assessment criteria for each lab exercise and any additional material will be available on the course Canvas site.
Return Method In Class
Feedback Provided In Class

Assessment 2 - Presentation

Assessment Type Presentation
Purpose To present research findings on the underlying theory and construction of various Imaging systems as well as associated signal processing techniques.
Description In this assessment item students will orally present their research findings from the project in assessment item 3.
Weighting 30%
Length 30 minutes
Due Date Week 13. Schedules for the individual presentations will be made available in Canvas.
Submission Method In Class
Assessment Criteria Available in the project specification on the course Canvas site.
Return Method In Class
Feedback Provided In Class

Assessment 3 - Project

Assessment Type Project
Purpose Conduct research and document research findings on the underlying theory and construction of various Imaging systems. In this project the students will apply various imaging, signal analysis and image analysis skills learnt in the course to solve practical problems. The students will also be required to demonstrate and present their solutions during marking.
Description This project will require the students to implement the underlying signal analysis algorithms on computer using some language (e.g. Matlab, C, Python) of their choice.
Weighting 40%
Due Date Progressive assessments, Week 4, Week 9 and Week 12
Submission Method Online
Source code submission is via Canvas. Students are also required to demonstrate and defend their solution in the lab.
Assessment Criteria Available in the project specification on the course Canvas site.
Return Method Not Returned
Feedback Provided No Feedback

Assessment 4 - Formal Examination

Assessment Type Formal Examination
Purpose The final formal examination is designed to test the individual student's knowledge of the course material and their ability to describe, analyse and hypothesise from this material.
Description The final exam will examine all material presented in the lectures, tutorials and laboratories.
Weighting 20%
Length 2 hours
Due Date Formal examination period
Submission Method Formal Exam
Assessment Criteria The final exam will examine all material presented in lectures, tutorials and laboratories.
Return Method Not Returned
Feedback Provided No Feedback

ADDITIONAL INFORMATION

Grading Scheme This course is graded as follows:

Range of Marks	Grade	Description
85-100	High Distinction (HD)	Outstanding standard indicating comprehensive knowledge and understanding of the relevant materials; demonstration of an outstanding level of academic achievement; mastery of skills*; and achievement of all assessment objectives.
75-84	Distinction (D)	Excellent standard indicating a very high level of knowledge and understanding of the relevant materials; demonstration of a very high level of academic ability; sound development of skills*; and achievement of all assessment objectives.
65-74	Credit (C)	Good standard indicating a high level of knowledge and understanding of the relevant materials; demonstration of a high level of academic achievement; reasonable development of skills*; and achievement of all learning outcomes.
50-64	Pass (P)	Satisfactory standard indicating an adequate knowledge and understanding of the relevant materials; demonstration of an adequate level of academic achievement; satisfactory development of skills*; and achievement of all learning outcomes.
0-49	Fail (FF)	Failure to satisfactorily achieve learning outcomes. If all compulsory course components are not completed the mark will be zero. A fail grade may also be awarded following disciplinary action.

*Skills are those identified for the purposes of assessment task(s).

Communication Methods

Communication methods used in this course include:

- Canvas Course Site: Students will receive communications via the posting of content or announcements on the Canvas course site.
- Email: Students will receive communications via their student email account.
- Face to Face: Communication will be provided via face to face meetings or supervision.

Course Evaluation

Each year feedback is sought from students and other stakeholders about the courses offered in the University for the purposes of identifying areas of excellence and potential improvement.

Oral Interviews (Vivas)

As part of the evaluation process of any assessment item in this course an oral examination (viva) may be conducted. The purpose of the oral examination is to verify the authorship of the material submitted in response to the assessment task. The oral examination will be conducted in accordance with the principles set out in the Oral Examination (viva) Procedure. In cases where the oral examination reveals the assessment item may not be the student's own work the case will be dealt with under the Student Conduct Rule.

Academic Misconduct

All students are required to meet the academic integrity standards of the University. These standards reinforce the importance of integrity and honesty in an academic environment. Academic Integrity policies apply to all students of the University in all modes of study and in all locations. For the Student Academic Integrity Policy, refer to https://policies.newcastle.edu.au/document/view-current.php?id=35.

Adverse Circumstances

The University acknowledges the right of students to seek consideration for the impact of allowable adverse circumstances that may affect their performance in assessment item(s). Applications for special consideration due to adverse circumstances will be made using the online Adverse Circumstances system where:

1. the assessment item is a major assessment item; or
2. the assessment item is a minor assessment item and the Course Co-ordinator has specified in the Course Outline that students may apply the online Adverse Circumstances system;
3. you are requesting a change of placement; or
4. the course has a compulsory attendance requirement.

Before applying you must refer to the Adverse Circumstance Affecting Assessment Items Procedure available at:
https://policies.newcastle.edu.au/document/view-current.php?id=236

Important Policy Information

The Help button in the Canvas Navigation menu contains helpful information for using the Learning Management System. Students should familiarise themselves with the policies and procedures at https://www.newcastle.edu.au/current-students/no-room-for/policies-and-procedures that support a safe and respectful environment at the University.

Other Information

Oral Interviews (Vivas)

As part of the evaluation process of any assessment item in this course an oral examination (viva) may be conducted. The purpose of the oral examination is to verify the authorship of the material submitted in response to the assessment task. The oral examination will be conducted in accordance with the principles set out in the Oral Examination (viva) Procedure. In cases where the oral examination reveals the assessment item may not be the student's own work the case will be dealt with under the Student Conduct Rule.

This course outline was approved by the Head of School on 30.06.2023. No alteration of this course outline is permitted without Head of School approval. If a change is approved, students will be notified and an amended course outline will be provided in the same manner as the original.

Graduate Profile Statements – MENG3451 – Semester 2 2023

This course builds students' capacity in the following University of Newcastle Bachelor of Engineering Graduate Profile Statements (based on 2011 Engineers Australia revised Stage 1 Competency Standards for Professional Engineers):

UON Att.	University of Newcastle Bachelor of Engineering Graduate Profile Statements/ Engineers Australia Stage 1 competency statements	Taught	Practised	Assessed	Skill Level (1-4)
	Professional Attributes				
11	3.1. Ethical conduct and professional accountability				
12	3.2. Effective oral and written communication in professional and lay domains.			✓	3
13	3.3. Creative, innovative and pro-active demeanour.				
14	3.4. Professional use and management of information.				
15	3.5. Orderly management of self, and professional conduct.				
16	3.6. Effective team membership and team leadership.				
	Engineering Ability				
7	2.1. Application of established engineering methods to complex engineering problem solving.	✓	✓	✓	3
8	2.2. Fluent application of engineering techniques, tools and resources.	✓	✓	✓	4
9	2.3. Application of systematic engineering synthesis and design processes.	✓	✓	✓	3
10	2.4. Application of systematic approaches to the conduct and management of engineering projects.				
	Knowledge Base				
1	1.1. Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline.	✓	✓	✓	3
2	1.2. Conceptual understanding of the, mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline.	✓	✓	✓	4
3	1.3. In-depth understanding of specialist bodies of knowledge within the engineering discipline.	✓	✓	✓	4
4	1.4. Discernment of knowledge development and research directions within the engineering discipline.	✓	✓	✓	3
5	1.5. Knowledge of contextual factors impacting the engineering discipline.				
6	1.6. Understanding of the scope, principles, norms, accountabilities and bounds of contemporary engineering practice in the specific discipline.				