BENG4018

Advanced Medical Imaging Systems

Session 1, Weekday attendance, North Ryde 2020

School of Engineering

Contents

General Information

Unit convenor and teaching staff
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Credit points
10

Prerequisites
BENG3016 or ELEC316

Corequisites

Co-badged status

Unit description
Magnetic Resonance Imaging (MRI) is a powerful medical imaging technique which is nowadays routinely applied in all major hospitals. A well-known advantage of MRI is its superior soft tissue contrast and its harmless character. Since its invention, MRI technology has known an enormous expansion both conceptual and in hardware development. This evolution has enabled quantitative mapping of different microstructural and physiological properties non-invasively. MRI comprises a growing field of multi-disciplinary research that involves physics, chemistry, biology, engineering, computational modelling, image processing and medicine. The aim of the course is to provide a comprehensive introduction to the physics of MRI. The course will cover the basic physics of nuclear magnetization and nuclear magnetic resonance, image formation, the hardware components of an MRI scanner, safety and health aspects of MRI scanning and advanced research techniques such as diffusion MRI, functional MRI, multi-nuclear MRI and hyperpolarized MRI. Finally, other experimental imaging techniques such as electrical impedance tomography (EIT), photo-acoustic imaging, Terahertz imaging, infrared (IR) imaging and diffuse optical tomography (DOT) will be discussed.

Important Academic Dates

Information about important academic dates including deadlines for withdrawing from units are available at https://www.mq.edu.au/study/calendar-of-dates

Learning Outcomes

On successful completion of this unit, you will be able to:

ULO1: Explain the physical principles behind nuclear magnetic resonance (NMR)

ULO2: Explain how an MRI image is created starting from the NMR signal acquisition and analyse an MRI pulse sequence

ULO3: Design and fabricate a basic radio-frequency (RF) MRI coil and the associated electronics.

ULO4: Perform quality assurance testing of MRI and recognize image artifacts.

ULO5: Explain differences between contrast weighted images and quantitative images and compare novel medical imaging techniques

Assessment Tasks

Coronavirus (COVID-19) Update

Assessment details are no longer provided here as a result of changes due to the Coronavirus (COVID-19) pandemic.

Students should consult iLearn for revised unit information.

Find out more about the Coronavirus (COVID-19) and potential impacts on staff and students

General Assessment Information

Notifications

Formal notification of assessment tasks, grading rubrics and due dates will be posted on iLearn. Although all reasonable measures to ensure the information is accurate, the University reserves the right to make changes without notice. Each student is responsible for checking iLearn for changes and updates.

Weekly Plan

A weekly plan of lectures, assignments, tests, laboratory and workshop sessions will be posted on iLearn. Students are expected to be aware of possible minor variations.

Assignment Tasks

Assignment questions will be posted on iLearn. Assignment solutions will be posted within one to five days after the submission date. Submissions will not be accepted once the solution is posted.

All assignments must be submitted electronically through iLearn (in pdf format). Submissions are expected to be typed in a logical layout and sequence. Markers WILL NOT grade poorly organized or illegible scans or drafts. Illegible scans or drafts are assignments that are handwritten or digital photographed with for example a smartphone. The expected workload includes preparation of final copies and clear diagrams. Resubmissions will be permitted up to due date.

All assignments should be prepared individually. It is expected that students consult tutors, lecturers or other students while learning the concepts, but copying assignments from others is

not accepted. Students are expected to have read and understood the academic honesty policy.

Absences

Late notices or absences from tests, workshops and laboratories will be considered under extenuating circumstances upon lodgement and approval of a formal notice of disruption of studies.

Grading

To obtain a passing grade (P/CR/D/HD) a total mark of 50% or more is required AND a mark of 50% or more is required for the final examination. The final exam is a hurdle requirement because it is the only reliable assessment of individual performance for this unit. A passing grade of 50% or more in the final examination is a condition of passing this unit. Students who make a serious attempt but fail to meet the hurdle requirement will be given one further opportunity to pass. A serious attempt is defined as achievement of a mark of 40% or greater.

Delivery and Resources

Coronavirus (COVID-19) Update

Any references to on-campus delivery below may no longer be relevant due to COVID-19.

Please check here for updated delivery information: https://ask.mq.edu.au/account/pub/display/unit_status

Delivery of this course is through a series of 13 theoretical lectures of 2 hours each and a series of practical sessions / tutorials.

The theoretical lecture series consist of 3 modules:

1. Nuclear magnetization, NMR signal formation and relaxation
2. MRI image formation
3. Advanced MRI applications: Quantitative and functional MRI

The practical sessions involve hands-on experimentation on an NMR spectrometer, an earth filed MRI system, an NMR relaxometer and a whole body clinical MRI scanner (after hours). MRI hardware components will be build in the MRI research laboratory.

Tutorials are designed around numerical exercises on image formation and image contrast. Students will also have the ability to present and discuss a literature study (one review paper) during the tutorials.

Technology used and required

- Word processing (MS Word, Latex, ...)
- Matlab (can be downloaded from the university depositories)
- Image visualization software (3DSlicer)
- Electronics bench (research and teaching laboratories)

- Powerpoint (or alternative presentation software (e.g. SliTex))
- Library and Internet search engines

Syllabus

De Deene Y, Magnetic Resonance Imaging - From Basic Principles to Advanced Techniques (A Biomedical Engineering Perspective)

Recommended books (optional)

- Haacke E M et al, Magnetic Resonance Imaging - Physical Principles and Sequence Design
- Bernstein M A et al, Handbook of MRI Pulse Sequences
- Tofts P, Quantitative MRI of the Brain - Measuring Changes caused by Disease
- Jin J, Electromagnetic Analysis and Design in Magnetic Resonance Imaging
- Levitt M H, Spin Dynamics - Basics of Nuclear Magnetic Resonance

Unit Schedule

Coronavirus (COVID-19) Update

The unit schedule/topics and any references to on-campus delivery below may no longer be relevant due to COVID-19. Please consult iLearn for latest details, and check here for updated delivery information: https://ask.mq.edu.au/account/pub/display/unit_status

Week	Lecture	Practical session / tutorial	Assignments
Module 1	***Nuclear magnetization***		
1	Introduction to quantum mechanics (QM)		
2	Nuclear magnetism: A classical and QM model	Problem solving: written exercises	
3	Nuclear spin interactions	Laboratory: NMR spectroscopy	NMR laboratory
4	Relaxation mechanisms	Laboratory: NMR relaxometry	
Module 2	***MRI image formation***		
5	MR imaging principles	Problem solving: written exercises	
6	MRI hardware 1	Visit and exercise on clinical MRI scanner (MQ hospital)	MRI acquisition
7	MRI hardware 2	Laboratory: NMR RF coil fabrication - tuning and matching	

Week	Lecture	Practical session / tutorial	Assignments
8	MRI safety and potential health effects	Laboratory: Low field MRI designs	MRI hardware
9	MRI sequence design 1	Problem solving: written exercises	
10	MRI sequence design 2	Problem solving: written exercises	Literature study
Module 3	***Advanced MRI applications***		
11	Quantitative MRI	Literature study: in-class critical discussion	
12	Functional MRI	Seminar by MRI researcher(s)	
13	Functional MRI	Tutorial: Questions and Answers	

Policies and Procedures

Macquarie University policies and procedures are accessible from Policy Central (https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central). Students should be aware of the following policies in particular with regard to Learning and Teaching:

- Academic Appeals Policy
- Academic Integrity Policy
- Academic Progression Policy
- Assessment Policy
- Fitness to Practice Procedure
- Grade Appeal Policy
- Complaint Management Procedure for Students and Members of the Public
- Special Consideration Policy *(**Note:** The Special Consideration Policy is effective from 4 December 2017 and replaces the Disruption to Studies Policy.)*

Students seeking more policy resources can visit the Student Policy Gateway (https://students.mq.edu.au/support/study/student-policy-gateway). It is your one-stop-shop for the key policies you need to know about throughout your undergraduate student journey.

If you would like to see all the policies relevant to Learning and Teaching visit Policy Central (https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central).

Student Code of Conduct

Macquarie University students have a responsibility to be familiar with the Student Code of Conduct: https://students.mq.edu.au/study/getting-started/student-conduct

Results

Results published on platform other than eStudent, (eg. iLearn, Coursera etc.) or released

directly by your Unit Convenor, are not confirmed as they are subject to final approval by the University. Once approved, final results will be sent to your student email address and will be made available in eStudent. For more information visit ask.mq.edu.au or if you are a Global MBA student contact globalmba.support@mq.edu.au

Student Support

Macquarie University provides a range of support services for students. For details, visit http://students.mq.edu.au/support/

Learning Skills

Learning Skills (mq.edu.au/learningskills) provides academic writing resources and study strategies to help you improve your marks and take control of your study.

- Getting help with your assignment
- Workshops
- StudyWise
- Academic Integrity Module

The Library provides online and face to face support to help you find and use relevant information resources.

- Subject and Research Guides
- Ask a Librarian

Student Services and Support

Students with a disability are encouraged to contact the Disability Service who can provide appropriate help with any issues that arise during their studies.

Student Enquiries

For all student enquiries, visit Student Connect at ask.mq.edu.au

If you are a Global MBA student contact globalmba.support@mq.edu.au

IT Help

For help with University computer systems and technology, visit http://www.mq.edu.au/about_us/offices_and_units/information_technology/help/.

When using the University's IT, you must adhere to the Acceptable Use of IT Resources Policy. The policy applies to all who connect to the MQ network including students.