ECE 780 / MedPhys 702  
Medical Imaging Systems II

COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR DESCRIPTION

This course will compliment Medical Imaging Systems I. In this course imaging methods that rely on non-ionizing radiation will be discussed. The course content focuses on magnetic resonance imaging (MRI), multinuclear spectroscopy (MNS) in vivo nuclear magnetic resonance (NMR) and ultrasound (US) methods. Advanced concepts such as multi-modality imaging approaches, image fusion, and functional medical image processing will be discussed.

SCHEDULE And MODE OF DELIVERY

The material for this course will be delivered through a mixture of in person lectures and visits to clinical research imaging facilities.

Lecture: Fridays, 9:00am-12:00pm. First lecture is September 8th, 2023
Location: See Avenue to Learn
Format: Synchronous in person

INSTRUCTORS

Dr. Michael Noseworthy PhD PEng
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Phone: (905) 525-9140 ext. 23727
Office: MUMC 3N-26E (Radiology offices)
Office Hours: By appointment

Dr. Kevin Diamond, Ph.D., MCCPM
Email: diamonkr@mcmaster.ca
Phone: (905) 387-9711 ext. 67145
Office: Juravinski Cancer Centre, room 4-46
Office Hours: By appointment

Of Note: This course will only be taught if 6 or more students are registered.

COURSE WEBSITE

All materials will be uploaded to the A2L course website: http://avenue.mcmaster.ca

COURSE OBJECTIVES

This course is designed to allow students to become familiar with medical imaging technologies both from a physics and engineering perspective through to a practical perspective. The course will focus on magnetic resonance techniques (e.g. MRI, in vivo NMR, etc.) and ultrasound (US)
methods. Occasional comparisons with other imaging modalities (e.g. PET, SPECT, DXA, mammography, CT, EEG, MEG) will be made where appropriate. In addition, throughout the course, students will learn the most frequent artefacts, their causes and potential solutions.

ASSUMED KNOWLEDGE

Students taking this course are expected to already have solid knowledge in electromagnetics, magnetic resonance imaging (MRI), and medical imaging in general. A working knowledge of anatomy and physiology is also assumed.

COURSE MATERIALS

Textbooks:

COURSE OVERVIEW

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic (Approximately)</th>
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<tbody>
<tr>
<td>1</td>
<td>Sept. 8th</td>
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<td>Sept. 15th</td>
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<td>3</td>
<td>Sept. 22nd</td>
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<td>Sept. 29th</td>
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<td>Oct. 6th</td>
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<td>Oct. 13th</td>
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<td>Oct. 20th</td>
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<td>Oct. 27th</td>
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<td>9</td>
<td>Nov. 3rd</td>
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<td>10</td>
<td>Nov. 17th</td>
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<td>11</td>
<td>Nov. 24th</td>
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1. Classical response of a single nucleus to a magnetic field, rotating and lab frames of reference; magnetization, relaxation and Bloch equation. RF pulses and signal detection. (MDN)
2. Introductory signal acquisition methods: free induction decay, spin echoes, inversion recovery, and spectroscopy. (MDN)
3. One and multidimensional Fourier imaging. Slice excitation and k-space. RF coils (surface coil, T/R switches, birdcage, phased array), B₁ and B₁+ fields, B₁+ mapping. (MDN)
4. Sampling (uniform and non-uniform), image reconstruction, signal, contrast and noise. (MDN)
5. Water/fat imaging and chemical selective / suppression methods. Fast imaging in steady state, fast/turbo spin echo, echo planar imaging, spiral and irregularly sampled imaging. (MDN)
6. FALL READING WEEK, no class
7. Magnetic field inhomogeneity effects and T2* dephasing. Electromagnetic properties of tissues, magnetic susceptibility, quantitative susceptibility mapping (qSM). (MDN)
8. Motion artifacts, motion sensitizing gradients, measuring spin motion using phase contrast, time-of-flight and diffusion. (MDN)
9. Advanced MRI applications: Functional MRI, diffusion and diffusion tensor imaging (DTI), 4D flow. (MDN)
10. Background, acoustical properties of tissues, propagation of sound waves, endogenous contrast, sources. (KD)
11. Multinuclear spectroscopy and imaging. Physiologically important non-proton nuclei, quadrupolar nuclei. Hyperpolarization (13C, 129Xe): SEOP and DNP. (MDN)

12. Diagnostic transducers, 2-D image formation, 3-D image formation, Doppler/colour flow imaging, performance testing/QA. (KD)
12 Dec. 1\textsuperscript{st} Imaging artefacts, biological effects and safety, exogenous contrast agents, elasticity imaging methods, focused ultrasound, ultrasound tomography. (KD)

13 Dec. 8\textsuperscript{th} STUDENT PRESENTATIONS. (MDN & KD)

A more detailed time line will be provided on the course web site.

At certain points in the course it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

**ASSESSMENT**

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<thead>
<tr>
<th>Component</th>
<th>Weight</th>
<th>Due Date</th>
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<tbody>
<tr>
<td>MRI Assignment 1</td>
<td>20 %</td>
<td>TBA</td>
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<tr>
<td>MRI Assignment 2</td>
<td>20 %</td>
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<tr>
<td>Ultrasound Assignment</td>
<td>20 %</td>
<td>TBA</td>
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<tr>
<td>Final Presentation</td>
<td>40 %</td>
<td>December 8\textsuperscript{th}, 2023</td>
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<td><strong>Total</strong></td>
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No make-up presentations will be granted.

**CONDUCT EXPECTATIONS**

As a McMaster graduate student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the Code of Student Rights & Responsibilities (the “Code”). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, whether in person or online.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students’ access to these platforms.

**COPYRIGHT AND RECORDING**

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, including lectures by University instructors.
The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

### Academic Accommodations of Students with Disabilities

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University’s Academic Accommodation of Students with Disabilities policy.

### Academic Accommodation for Religious, Indigenous or Spiritual Observances (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office *normally within 10 working days* of the beginning of term in which they anticipate a need for accommodation or to the Registrar’s Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

### Extreme Circumstances

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.

### Research Ethics

The two principles underlying integrity in research in a university setting are these: a researcher must be honest in proposing, seeking support for, conducting, and reporting research; a researcher must respect the rights of others in these activities. Any departure from these principles will diminish the integrity of the research enterprise. This policy applies to all those conducting research at or under the aegis of McMaster University. It is incumbent upon all members of the university community to practice and to promote ethical behaviour. To see the Policy on Research Ethics at McMaster University, please go to [http://www.mcmaster.ca/policy/faculty/Conduct/ResearchEthicsPolicy.pdf](http://www.mcmaster.ca/policy/faculty/Conduct/ResearchEthicsPolicy.pdf).